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ON THE SOCIAL EPISTEMOLOGICAL NATURE OF QUESTIONS:  
A COMPARISON OF KNOWLEDGE DOMAINS' QUESTION FORMULATIONS ON  
THE TOPIC OF "MEMORY"

By

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## **ABSTRACT OF THE DISSERTATION**

On the social epistemological nature of questions: A comparative analysis of knowledge domains' question formulations on the topic of "memory"

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If "information" is a central concept for library and information science, then "questions" are fundamental, for information "informs" relative to the question. But research focusing on questions as a central theoretical concept has been stymied by the paradox of the question, which observes that in order to ask one must know enough to know what one does not know (Flammer, 1981). This dissertation proposes that this paradox results from the limitations of the cognitive approach to questions as indications of individual information need, and that the paradox can be resolved by reframing questions as social epistemological tools of inquiry within knowledge domains. The questions posed by three knowledge domains – neuroscience, literature, and computer engineering – on the common topic of "memory" are analyzed in order to investigate how the domains' question formulations compare and what the comparisons convey about how to answer and the assumptions upon which question and answer are constructed. A method is developed for identifying the implicit questions that motivate and organize scholarly inquiry by analyzing dissertation abstracts as knowledge products of inquiry. The comparative question analysis of neuroscience, literature, and computer engineering

dissertations' question formulations about "memory" supports the proposition that knowledge domains ask different questions and ask them differently. What they ask, the content of their questions, communicates the indeterminate epistemic situation that each domain has of memory, while the mode of presentation of the question, its form, conveys the epistemic structure of inquiry and the production of knowledge. A social epistemological model of domains' question formulations is developed that proposes that question content reflects domain ontologies, question form reflects domain epistemologies, and determinations of question relevance reflect domain sociality, which model has implications for document relevance, question negotiation, information retrieval design, and inquiry-based learning.

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## CHAPTER 1: INTRODUCTION

Question asking is one of those mundane and everyday activities which [sic] we spend considerable time engaged in yet have a very rudimentary technical understanding of. Ask people you know to tell you why they ask the questions they do. A shrug. Or why they ask questions at all. They will probably respond (if they don't think the question too absurd) by telling you that they ask questions to find out something they don't know. But ask them *how, out of all the possible things they don't know when they ask a question, do they choose to ask a particular question, in a particular way*. Wouldn't another question have been as good? *Ask them if they think questions also convey information as well as request it [emphasis added]*." (Kearsley, 1976, p. 355-6)

### 1.1 Background: Why study questions?

Any theory of information needs to begin with a theory of questions (MacKay, 1969). In the ongoing debate about whether "information" is the central object of interest in library and information science (LIS) and if so how it should be defined, the theoretical significance of the question has been neglected. If "information" is most literally defined as "that which informs or has the potential to inform," one might ask what information "informs" in relation to. One communications scholar, challenging a LIS audience to reflexive research, puts it this way: "Information may be the answer, but what is the question?" (Halloran, 1983, p. 159). From the simplest request for information ("What time is it?"), to the deepest metaphysical inquiries ("Why are we here?"), questions are the "functional interface of the inquiry process" or "an instrument for inquiring" (Horne, 1983, p. 5). To pose a question is to admit one's lack of knowledge about something and a desire and intention to remedy that lack. The question plays an "organizing function" (MacKay, 1960, p. 790) by pointing back towards its assumptions and simultaneously looking forward towards what constitutes an answer. Questions precede information.

What might it look like, then, to consider the *question* as a more fundamental concept for organizing the universe of documents than information? “Information” is an ambiguous term with a variety of meanings, including: information-as-process, information-as-knowledge, information-as-thing (Buckland, 1991); information as selective, information as general phenomenon, information as category and property of matter, information as semantic, information as event, information in relation to uncertainty, information as structure (Belkin, 1978); as well as information as relevance (Furner, 2004). The conflicting conceptions of and ensuing debate about “information” creates a tendency towards generalized abstractness or else makes necessary the articulation of which exact information concept is being employed. Questions, on the other hand, are undeniably contextual. In their formulation and presentation, questions reveal a wealth of information about questioners’ assumptions and their criteria for what constitutes an answer. Subsequent to understanding what constitutes an answer, judgments of document relevance can be made. Consequently, a better understanding of questions is necessary to inform information scientists’ and practitioners’ efforts to structure the universe of recorded documents to promote its effective and efficient navigation in the continual production of new knowledge. If LIS is concerned with helping people to navigate the universe of recorded documents, then the study of questions and what they reveal about questioners’ criteria for what constitutes an answer and the criteria for documents relevant to producing the answer is of utmost importance to theoretical and practical advancement.

## **1.2 Problem statement: The paradox of the question and the problem of context**

While questions have long been an object of study in library and information science, theoretical and methodological insight into the role of the question in inquiry and the production of knowledge has been stymied by what one psychologist identifies as the *paradox of the question* (Flammer, 1981): questioners are required to formulate questions to solicit precisely the information that they lack. The paradox of the question states that in order to ask for the needed information, the questioner has to know enough to know what can be known. This paradox is taken to its logical extreme in Taylor's (1962) observation, "By asking a question, the inquirer imposes limits on the information acceptable as an answer. The converse of this statement is the postulate that knowing what counts as an answer is equivalent to knowing the question" (p. 393).

Taylor's (1968) research on question negotiation works within this paradoxical assumption to develop a model of the increasingly opaque question expressions, from the initial inception in the mind of the questioner, to its presentation to the information system being approached by the questioner. Taylor's description of the four levels of question formation and information need offer a conceptualization of the communicative complexity of even the most basic reference encounter. Librarians have long been witness and party to the opacity of language and the paradox of the question in the context of information intermediation. The question as it is explicitly stated can only be effectively understood and answered when viewed in relation to what, by the questioner's intention or inability, remains implicit or unstated – what too often is relegated to the black box of "context" – or by the recipients' inability to comprehend the stated question and its implicit context. In order to negotiate or disambiguate the question context,

reference librarians are taught to probe questioners about their context: task criteria, search history, cognitive level, and practical constraints such as time limits and physical access to resources such as the Internet, special libraries, or library databases. A search engine or digital library interface might similarly prompt the user to add additional search parameters or proactively suggest relevant or related search terms.

The importance of *context* in relation to information and communication is widely agreed upon, but little else in relation to context is. Dervin (2003) writes that “there is no term that is more often used, less often defined, and when defined defined so variously as context” (p. 112). Depending on contextual elements such as the functional constraints of the information system or the questioner’s cognitive ability, social location, task, situation, culture, environment, time, and place, to name a few, a stated question can be interpreted in an endless number of ways, with each interpretation resulting in different criteria for documents that might assist in the inquiry process. It is the contextual nature of the question that suggests that questions are not mere requests for information, but have important communicative properties beyond delineating the topic of the inquiry. Questions convey information as well as request it, but what information is being conveyed? An approach to conceptualizing questions that can account for the problem of “context” is essential to unlocking the question paradox, both for the purpose of aiding information organization and intermediation and in the interest of developing relevant theories of information. This is the problem that lies at the center of the current investigation.

### **1.3 Statement of purpose**

This dissertation seeks a way out of the question paradox and the problem of context by conceiving of questioning as a social epistemological phenomenon and questions as social epistemological objects, asking how questions can be recast as tools of knowledge production within the context of knowledge domains rather than indications of individuals' cognitive information needs. Towards this end, three contrasting knowledge domains' dissertation research on a common topic will be compared in order to determine how their question formulations compare, what the comparisons reveal about how to answer and the domain assumptions upon which questions and answers are constructed, and the theoretical, methodological, and practical implications of this paradigmatic shift in question research. In doing so, this research seeks to re-establish the fundamental importance of the question as a concept for library and information science by illustrating how different question formulations function to organize inquiry according to the specific nature of knowledge production in each domain. This domain-based understanding of the question is proposed as the most fundamental context for understanding inquiry, which is the process by which knowledge is produced, and thus the foundation for theories and practices of information behavior and knowledge organization.

### **1.4 Research questions**

The overarching research question guiding this investigation is: *How do knowledge domains' question formulations about a common topic compare and what do they convey about the answers that follow and the assumptions that precede the questions?* The following research questions will further guide the investigation.

- I. What questions do different knowledge domains formulate about a common topic?
- II. How do the knowledge domains' question formulations compare?
- III. What information do the comparisons between knowledge domains' question formulations convey about the answers that follow and the assumptions that precede the questions?

The questions guide the investigation in incremental stages, from identification of knowledge domains' questions, to their comparison, to interpretation of the comparisons. The first question requires the development of a method for identifying domains' question formulations from the knowledge products of inquiry and for characterizing the types of questions within and across domains. Question two considers how to categorize and compare the types of question formulations in each domain. The third question pivots to turn a theoretical lens on the relationships between questions, answers, and assumptions, as well as between question formulations and the knowledge domain as a context for inquiry and the production of knowledge. A social epistemological model of domains' question formulations is presented that links the dimensions of question formulations (content, form, relevance) to dimensions of the knowledge domain (ontological, epistemological, social).

### **1.5 Statement of rationale**

All human inquiry begins with a question, is guided throughout by the question, and ends when the question has been answered or resolved. It is the unacknowledged framework for all human interactions with information, even for "accidental" or "unintentional" information encountering, such as described by Erdelez (1997), for

information only informs relative to a question. The question may be implicit or only emergent at the point of encountering the data, which becomes information at the point of its relation to the question. Without acknowledgement of the question as framework for inquiry and the knowledge domain as the social context of inquiry, the empirical study of information behaviors and practices is susceptible, at its worst, to wayward interpretations or, at the very least, piecemeal understanding of humans interactions with information in the production of knowledge.

Furthermore, the comparative epistemological methodology directs theoretical attention to the formal dimensions of human-information phenomena such as question formulation. A comparative lens produces knowledge that cuts across the historic focus on subject-oriented user groups, suggesting a way forward for theoretical advancement of LIS, which Bates (1999) describes as a meta-discipline whose study is the content of form and organization of information. The current investigation demonstrates that comparative research can simultaneously produce knowledge of specific knowledge domains' question formulations and the nature of questioning as a general phenomenon of human-information interaction.

## **1.6 Definition of terms**

The following concepts are central to the current investigation. Definitions have been derived from reviews of the existing literature, with an eye toward the specific perspective and goals of this study. Concepts will be further discussed throughout the dissertation.

**Inquiry.** Inquiry is the directed or controlled transformation of an indeterminate situation into a determinate one (Dewey, 1938). It is both natural and cultural: natural in

the sense that it has its foundations in the biological activities of humans, and cultural, in that it is a socially conditioned mode of activity with cultural consequences (Dewey, 1938). Inquiry is conducted through the asking and answering of questions (also referred to as “questioning”) in a manner that accords with the norms and practices of the knowledge domain or domains of origin. The result of competent inquiry is the production of knowledge (Dewey, 1938).

**Knowledge domain.** Knowledge domains are the basic social unit of inquiry and the foundational context for all information practices and behaviors. Domains have ontological, epistemological, and social dimensions (Hjørland and Hartel, 2003b). Domains can be scholarly, scientific, or affiliated with everyday knowledge producing contexts such as religion, politics, or professional trades and hobbies (Hjørland, 2010).

**Knowledge.** Knowledge is the product of competent inquiry (Dewey, 1938). It is the sum total of what is known, the “warrantably assertible conclusions” (Dewey, 1938), about the world possessed by or in relation to knowledge domains. As a question seeks to produce an answer, inquiry seeks to produce knowledge.

**Question.** Questions are epistemic devices, tools used to transform indeterminate situations into determinate ones in relation to knowledge domains as social units of knowledge production. The indeterminate situations that questions seek to transform are of several types, including epistemic gaps, epistemic conflicts, and problems. Questions are a combination of *indication* and *invitation* (MacKay, 1960): they indicate the indeterminate epistemic situation and invite its resolution.

**Question formulation.** A question formulation is the precise expression of the indeterminate epistemic situation that is seeking transformation. Question formulations

have both content and form, and are subject to knowledge domains' norms and practices of inquiry. "Question" is used to indicate the abstract concept, while "question formulation(s)" refers to the operationalized expression of the concept.

**Question content.** The content of the question expresses *what* is being asked about, the indeterminate epistemic situation that motivates inquiry and seeks resolution. Question content is comprised of *subjects*, the entities of uncertain epistemic status, and *queries*, the types of determinations being sought about the entities.

**Question form.** The form of the question expresses *how* the question content is being presented. At the domain level of discourse, the epistemic form of the question conveys how inquiry is organized or components of inquiry are defined, as well as illustrating the relationships among the components of inquiry. Whereas question content conveys the epistemic determinations that the questioner seeks to make, question form functions as the device or tool used to make the determinations.

**Answers.** Answers are the determinations that resolve the indeterminate situations expressed in questions. The type of determination in an answer corresponds to the type of indeterminacy indicated in the question: epistemic gaps are answered by filling the gap with new information; epistemic conflicts are answered by resolving the conflict; problems are resolved with solutions. The content and form of the answer follows that of the question.

**Assumptions (of questions).** Questions are formulated on the basis of tacit beliefs in the knowledge domain about the nature of inquiry and the production of knowledge. Chief among these assumptions are ontological commitments, or beliefs about what entities exist in the world, their features and relations, and epistemological

presuppositions, or beliefs about what can be known and how it is known. Domain assumptions precede question formulation.

## CHAPTER 2: LITERATURE REVIEW

By asking a question, the inquirer imposes limits on the information acceptable as an answer. The converse of this statement is the postulate that knowing what counts as an answer is equivalent to knowing the question. (Taylor, 1962, p. 393)

### 2.1 Introduction

A review of the major theories of library and information science suggests that, with some notable exceptions, questions are hardly ever the direct object of study but are often the implicit frame for information retrieval and information behavioral research. Most of the major theories and concepts of information seeking, including Dervin's (1992) Sense-Making, Kuhlthau's (2004) Information Search Process, Chatman's (1999) theory of life in the round, Belkin's (1978) concept of anomalous states of knowledge, and Wilson's (1983) concept of cognitive authority, presume that information seeking behaviors result from the existence of a question and the individual's inability to answer the question with the information that they currently possess. In order to understand what constitutes a relevant document that can provide an answer or assist in the production of an answer, one must understand what constitutes an appropriate answer. In order to understand what constitutes an appropriate answer, one must understand the question. The following review of the literature assesses the state of knowledge about questions and question-related phenomena of interest to library and information science (LIS) by conducting a meta-theoretical analysis of the question research in LIS. Before proceeding, the review of question research in LIS is contextualized in relation to the broader notion of "inquiry," the multidisciplinary nature of questions and questioning, and varying approaches to defining the "question."

**2.1.1 Inquiry and its relation to questions.** The understanding of inquiry in this dissertation draws from Dewey's (1938) logical philosophical discourse on the theory of inquiry. Dewey defines inquiry as "the directed or controlled transformation of an indeterminate situation into one that is so determinate in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole" (p. 104-5); in short, inquiry is the determination of an indeterminate situation. Dewey prefers the concept of "indeterminate situation" to the alternative "problematic situation" (which concept was introduced in the LIS research by Wersig (1979)) for the reason that a situation is not inherently problematic, but only becomes so upon being subjected to inquiry. An indeterminate situation is one in which the inquirer's experience of their environment is unsettled, and its constituent elements cease to "hang together." The expression of the manner in which the inquirer experiences the situation as indeterminate determines what is required for it to be transformed into a determinate situation. If the transformation is conducted in a directed or controlled manner that ends in a "unified existential situation," inquiry can be deemed as "competent" (Dewey, 1938).

The current investigation views the controlled and directed activities that transforms an indeterminate situation into a determinate one as centered on the asking and answering questions. Dewey (1938) asserts that up to a certain point, inquiry and questioning are synonymous, that we inquire when we question and when we seek an answer to a question. Inquiry is conducted by asking and answering questions. What remains implicit in this statement of inquiry as conducted by the asking and answering questions is the complex social epistemological context within which the inquiry occurs. While inquiry has naturalistic foundations (as the use of humans' sense organs is a

necessary condition of inquiry), how inquirers see, hear, measure, build, read, think, make decisions, and use language – all of the elements of inquiry – are shaped by culture (Dewey, 1938).

Dewey (1938) distinguishes common sense inquiry from scientific inquiry as that which draws its significances and meanings in reference to the application of the resultant knowledge. In contrast, scientific inquiry is directed the production of knowledge that is coherent and consistent with existing knowledge. Knowledge resulting from common sense inquiries is meant to settle issues of use and enjoyment of the environment, while knowledge resulting from scientific inquiry exists for its own sake. The use of the term “inquiry” in this dissertation is intended to encompass both common sense and scientific inquiry, at the conceptual level, but at the empirical level only scientific (more commonly referred to in LIS as “scholarly”) inquiry is investigated.

As inquiry is here understood as being conducted by asking and answering questions, questions are defined as tools of inquiry. Derr’s (1982) definition of questions as linguistic devices, tools used to make epistemic determinations is here combined with Dewey’s (1938) definition of inquiry as the directed and controlled transformation of indeterminate situations into determinate ones, in order to define *questions as epistemic devices, tools used to transform indeterminate situations into determinate ones*. Questions function to transform indeterminate situations into determinate ones by guiding and organizing all aspects of inquiry, including: identification of subject matter, choice of sources of evidence, methods of analysis and reasoning, understanding what constitutes an answer, how to present it, and how to evaluate the quality of the answer. Horne (1983) aptly captures the utility of questions as a tool of inquiry in her definition of

questions as “the functional interface of inquiry” (p. 5). The term “inquiry” is used throughout the dissertation to refer to the practice of asking and answering questions, rather than any specific instance of it.

**2.1.2 Multidisciplinary nature of question research.** As a fundamental phenomenon of human knowledge, questions have been studied in many disciplines, each with its own conceptualization of what constitutes a “question,” methods of investigation, and types of findings. In a review of the multidisciplinary study of questioning, Dillon (1982) divides the literature into three basic categories: theoretical research as is conducted in philosophy, linguistics, erotetic logic, and cognitive psychology; the empirical research of social anthropology, sociolinguistics, and survey research; and practical research that focuses on how to ask questions to obtain desired effects, such as occurs in education, counseling, personnel interviewing, and legal cross-examination. Dillon (1982) includes library science in the practical research category, as is exemplified by Slavens’ (1978) book, *Informational Interviews and Questions*, in which common reference questions are grouped according to the type of reference source (directories, yearbooks, dictionaries, etc.) that should be used by reference librarians to answer the questions. Four fields of analysis emerge from Dillon’s (1982) review: linguistic analysis, concerned with the nature, structure, and meaning of questions as language events; education, the oldest and largest field, mostly concerned with the teachers’ use of questions as a pedagogical technique; practical pursuits such as opinion-polling, cross-examination, personnel interviewing, and psychotherapy; and scholarly inquiry, which is concerned with the formulation of questions in the pursuit of knowledge.

It is of particular interest to note the importance that Dillon (1982) attributes to the field of scholarly inquiry, "...where the fewest questions are posed, where the choice of question is of the most consequence, and where the resulting answer is of the greatest significance. Here also is where the least is known about questioning" (p. 156). LIS is uniquely qualified to contribute to the field of scholarly inquiry, as it has long been interested in both the pragmatic functions of questions and theories of scholarly communication. The two areas of question research and scholarly inquiry have, however, been largely isolated from each other, and is a reflection of the broad separation between the LIS fields of human information behavior and scholarly communication. Dillon's (1982) observation, that many disciplines study questions in relative isolation from each other even as their complementary approaches and findings have potential to inform each other, easily applies to this divide as well: user studies can gain depth from being placed in the context of the bigger picture of scholarly communication systems and structures, while scholarly communications research can be particularized by user studies.

**2.1.3 Defining "questions."** One of the difficulties in assessing what is known about questions and questioning is that there is no agreement in the literature as to what constitutes a "question," if and how they can be identified, and what can be known about them. From the perspective of question answering research in computer science and linguistics, questions are identified by their syntactic or linguistic features, such as a question mark at the end of a written sentence or rising intonation at the end of an utterance (Lauer, 2001). In this view, questions are verbally expressed requests for information. A question can also be defined in cognitive behavioral terms, such as Horne's (1983) definition of a question as "an observable behavioral act reflecting

information need, and proceeds from a series of cognitive processes produced by the need ‘to know’” (Horne, 1983, p. 5). The “information need” emerges from a cognitive state characterized by the lack of information or conflicting information; through the question, the mind seeks to re-establish equilibrium (Farmer, 2007, p. 41). In short, the question is a behavioral indication that an information need exists, but is not an exact representation of the information need (Swigger, 1985). This definition casts some doubt or at minimum complicates the assumption of the one-to-one mapping between the expressed question and the underlying information need. Questions are born of the user’s inadequacy: they indicate that the learner’s “cognitive structure is not adequate to the task” (Ford, 1980, p. 100). Questions serve “to expose you to a certain incompleteness in his picture of the world – an inadequacy in what we might call his ‘state of readiness’ to interact purposefully with the world around him and specifically with you” (MacKay, 1960, p. 789).

Ultimately, questions seek to elicit a response (Kearsley, 1976).<sup>1</sup> Responses have two functions: epistemic and interpersonal. The epistemic function of a question is to produce knowledge, fill a knowledge gap, or resolve an epistemic conflict, as reflected in Derr’s (1982) definition of questions as “linguistic devices...tools which [sic] we use to make epistemic determinations about the world” (p. 69). In the LIS literature, Eichman (1978) distinguishes between the use of questions to correct knowledge deficits (epistemic function) and the use of questions to monitor common ground (interpersonal function). While the epistemic and interpersonal functions seem to

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<sup>1</sup> Even rhetorical questions can be said to elicit a response by stimulating the thoughts of the respondent, though the respondent is not expected to verbalize the thoughts.

suggest two different kinds of responses, all responses encompass both functions, though one may be emphasized over the other. MacKay's (1960) definition of a question as "a combination of an indication and an invitation" reflects the dual functions of the question. Questions expose an inadequacy in the questioner's ability to interact purposefully with the world (indication of epistemic gap) and ask the respondent<sup>2</sup> to help remedy the inadequacy (invitation to respond) (MacKay, 1960).

In addition to the linguistic and cognitive conceptions of the question, philosophers also talk about the question in existential terms, as simultaneously representing inadequacy and potential. To ask a question is to inhabit a state of "being in the middle," between knowledge and ignorance, actuality and possibility (Gelven, 2000). To ask a question is also to be poised on the brink of action, putting the questioner "to the test...on the sharp side of the edge between yes and no" (Struyker Boudier, 1988). The existential perspective emphasizes the revelatory nature of the question rather than its functions. Struyker Boudier (1988) describes the question as revealing and exposing the questioner's stance in the world:

In strictly linguistic terms, the question should be interpreted as a request for an answer.... If viewed social-communicatively and philosophical-  
anthropologically, however, the question has a much wider purpose. *It may be interpreted as a pre-eminent way to show who or what the person 'is' or where he*

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<sup>2</sup> The definition of a respondent depends upon to whom the question is posed and from whom the answer is being sought. Most often, questions are thought of as being posed to another person, but questions can also be posed to a collective, one's own self, or the representations of an individual's or collective's knowledge, such as a document or the knowledge structures that mediate between questioner and document, i.e. search engine or search interface.

*stands* [emphasis added], just as the questions about things makes it possible for them to be exposed in the light of the truth. (p. 13)

By asking a question, particularly in the case of philosophical or metaphysical questions, the questioner is exposed. As a demonstration of the revelatory nature of questions, consider asking a number of individuals what questions they have about life after death. Inevitably, the questions reveal as much as they request; they will indirectly or directly reveal personal and cultural history, philosophical viewpoints, institutional affiliations, biases, styles of thinking, levels of existing knowledge, and more.

In light of these various definitions and conceptions of the question, what can be commonly agreed upon is that: (1) questions indicate a need for information; (2) they invite an answer or reply; and (3) they convey information about the questioner.

**2.1.4 Question research in library and information science.** In a survey of the question research in library and information science, Swigger (1985) groups the research according to the three question-related topics: questions and answers, questions and questioners, and question negotiation. Each topic can be mapped to one of the “isms” or meta-theoretical approaches of information science described by Talja, Tuominen, and Savolainen (2005). The topic of questions and answers can be described as taking an information transfer meta-theoretical perspective that centers on the question as object. Research on questions and questioners and question negotiation takes the meta-theoretical approach of cognitive constructivism and implicitly locate the question in the context of the individual questioner’s “problematic situation” (Wersig, 1979). The approach that is least defined in the existing literature, and which the current investigation takes, focuses on question as an intersubjective practice that occurs in the

context of knowledge domains. Table 1 shows the relationship between the meta-theoretical approaches, paradigms, and topics.

Question paradigm	Question-as-object	Questioner-as-subject		Questioning-as-intersubjective
Meta-theoretical approach in LIS (Talja, Tuominen & Savolainen, 2005)	Information transfer model	Cognitive constructivism		Collectivism (Social constructivism); Constructionism
Question-related topic (Swigger, 1985)	Questions and answers	Questions and questioners	Question negotiation	Questioning practices
Context of the question	Information system	Individual's problematic situation	Interaction between questioner and information intermediary	Knowledge domain
Type of relevance	Topical and objective (system-centered) relevance	Situational and subjective (user-centered) relevance (Talja, Tuominen, & Savolainen, 2005); psychological relevance (Harter, 1992)		Epistemological (domain-centered) relevance

**Table 1. Categories of question research in LIS**

These broad categories of research serve as ideal types that maximize analytical difference, but the boundaries between categories are porous and individual studies often include elements of more than one category.

The following sections, labeled according to the context of the question and the associated paradigmatic approach, update Swigger's (1985) review of the research literature on questions. By progressing through the paradigmatic stages of question research, an argument will emerge for a constructionist paradigm in which questioning is conceptualized as an intersubjective practice of knowledge domains. The questioning-as-intersubjective paradigm is proposed as a fruitful foundation for future question research, as it resolves some of the conceptual and methodological limitations of the other paradigms that have resulted in diminished scholarly attention to the question in LIS.

## 2.2 The information system: Question-as-object

The conceptualization of question-as-object is characterized by “a prima facie approach to questions, assuming that the way in which they are stated is perfectly clear, need no disambiguation, and perfectly conveys an information need” (Pomerantz, 2005, p. 717). Question-as-object has its roots in what Talja, Tuominen, and Savolainen (2005) label the information transfer model meta-theoretical approach. In this approach, information operates within a physical paradigm in which reality is objective and knowable and is captured in information, which is a “brick-like” entity. Information has objective meaning that can be transferred between sender and receiver with little loss of meaning (Dervin, 1994). Accordingly, the question is taken as an unproblematic request for information: “an interrogative statement requiring an answer, a statement which is a verbalized (oral or written) representation of an information need” (Saracevic, 1980, p. 146). More simply put, “A question is a formalized request for information” (Keyes, 1996, p. 238).

The primary mode of question research in information science is analysis of existing questions in order to create or improve question-answering tools and service. Both library reference services research and information retrieval (IR) systems research concern question-answering systems: physical libraries, on the one hand, and digital libraries or information systems, on the other. This research considers how information intermediaries (reference librarians) or technologies (automated algorithms) can better interpret the question in order to improve question-answering capabilities. Aptly categorized as “questions and answers” research by Swigger (1985), the research is organized around a shared problem: increasing information systems’ efficiency, variously

defined as volume of service, accuracy, user satisfaction, etc., in answering questions. The question is analyzed for its components or properties that indicate criteria for the selection of documents relevant to the production of an answer. The studies and their findings are discussed below according to these question components or properties: subject or topic; syntax and grammatical status; conceptual presupposition; reference categories; and information retrieval facets.

**2.2.1 Subject or topic.** Most fundamentally, the question reveals the subject or topic of interest to the questioner. In library science, there is a long history of classifying reference questions by subject or topic in order to inform collection development and develop best practices for reference services. Conner's (1927) analysis of question subjects for a *Library Journal* article on "What a reference librarian should know" is an early example of this type of question classification research. Conner classifies the reference questions asked at the Carnegie Library of Pittsburgh from 1905 to 1925 according to broad Dewey Decimal classes (General, Philosophy, Religion, Sociology, Philology, Fine Arts, Literature, History), as well as by prominent contemporary topics (the suffragists movement, evolution, the Montessori method of education, etc.). Knowledge of the subjects and topics of interest to the public should, she suggests, determine the college courses taken by those interested in working in public libraries and the planning of graduate courses in book selection, classification, and reference. In conceptual terms, questions are reduced to the subject or topic on which information is being requested. The question is taken at face value as a request for topical information. To this day, subject classification remains the central organizing principle for librarianship.

**2.2.2 Syntax and grammatical status.** The syntax of the question can also be analyzed for clues as to the nature of the question and what kind of answer is required. In his review of question taxonomies, Pomerantz (2005), drawing on Robinson and Rackstraw's (1972) linguistic analysis of questions, identifies the most basic classification as "the five Ws": who, what, when, where, and why<sup>3</sup>. He notes that several question-answering systems use wh- words as the primary criterion for determining the type of answer expected. Saracevic (1980) similarly lists grammatical status as one of the possible question properties for classifying questions en route to producing search results, defining it as the "(i) type of words and phrases and syntactic constructs in a question, and (ii) frequency distribution of words and phrases within one or many questions" (p. 147).

In reference studies, syntax is considered in the study of librarians' use of open- and closed-ended questions in the reference interview (King, 1972; White & Iivonen, 2001; Dervin & Dewdney, 1986). Open questions are more effective in eliciting query clarifications, but many librarians ask predominately closed-ended questions (Dervin & Dewdney, 1986; Marsteller and Mizzy, 2003; Radford, Connaway, Confer, et al., 2011). Whether they concern the initial use of questions by information seekers or subsequent questioning by reference librarians in negotiating information seekers' questions, these studies presume that the syntax of the question conveys expectations about the informational nature of the answer and the manner of its production.

**2.2.3 Conceptual presupposition.** A research project funded by the National Science Foundation and supervised by Tefko Saracevic and Miranda Pao at Case Western

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<sup>3</sup> Commonly, "how" is added to the list, to comprise the "five Ws and one H" of information gathering.

Reserve University entitled “Classification and Structure of Questions in Information Retrieval,” aimed to classify questions in order to improve accuracy of information retrieval systems. As a part of this project, Derr (1982; 1984) breaks down questions into the structural components of subjects and queries. By abstracting the subject (“X”), Derr identifies the query’s conceptual presuppositions, the basic concepts that define the kinds of question being asked. Table 2 shows Derr’s (1982) classification scheme.

I.	Existence	(Does X exist?)
II.	Identity	(What is X?) (Who is X?)
III.	Properties	(What are the features of X?)
IV.	Relation	(How is X related to Y?)
V.	Number	(How many X are there?)
VI.	Location	(Where is X?)
VII.	Time	(When is X?)
VIII.	Action	(What is X doing?)

**Table 2. A classification of questions in information retrieval by conceptual presupposition (Derr, 1982)**

In a study of users’ questions and their effectiveness in retrieving relevant documents, Saracevic and Kantor (1988) similarly classify questions according to “presuppositions,” operationalized as the presence and number of implied concepts that can be expressed as search terms. Questions’ presuppositions provide parameters for the system to understand what constitutes an answer to the question.

**2.2.4 Reference categories.** The practice of classifying reference questions in order to inform collection development and references service takes as its implicit context the library as an information system, in what has been identified as the system-centered perspective (Dervin & Nilan, 1986) in librarianship. Questions are categorized in order to evaluate existing library services and to improve the efficiency of the services and the library system as a whole. Beyond the question’s explicit subject or topic, the

information system dimensions identified as facets by which questions can be classified in order to improve the efficiency of reference service provision include: the library department as source of answer (Braxton & Brunsdale, 2004; Marsteller & Neuhaus, 2001); type of reference question (Katz, 1997; Cobine & Mohanty, 2005); type of resource the patron is inquiring (DeGroot, Dorsch, Collard, & Scherrer, 2005); type of resource used by librarian to answer (Goda & Bishop, 2008); and level or type of librarian skill required (Warner, 2001).

By classifying reference questions according to these dimensions, the library-as-information-system can improve its efficiency in answering questions. What is not addressed is the issue of whether the questions that are posed are actually representative of the questioner's "true" question, in other words, whether the spoken question can indeed elicit the answer or relevant documents that the questioner needs. Nevertheless, there is an intuitive grasping of the social and epistemological nature of information in some of the classificatory dimensions. For instance, when the library department reflects a division along subject disciplines, it can be seen as a proxy for the questioners' social epistemological context. Also, the type of library information/resource patron is inquiring about and type of resource used by librarian to answer reflect an understanding of the importance of form in terms of criteria for justifying answers in different disciplines.

**2.2.5 Information retrieval facets.** Information retrieval researchers similarly seek to classify questions in order to improve the ability of the automated information system to produce documents that are "relevant," in the sense of containing partial or complete answers to the questions. Unlike the reference encounter, which is often

described as more art than science due to the communicative intelligence that is required, information retrieval as executed by databases, online public access catalogs, and digital libraries automates the encounter, effectively rendering the “art” of reference into “science” – and thus subject to scientific experimentation. To disambiguate the question is the first step in knowing what an answer might look like and figuring out how to automate the retrieval of relevant documents. Information retrieval research situates questions in the implicit context of the automated information system. Beyond the question’s subject, syntax, and conceptual presuppositions, the retrieval of relevant documents is influenced by: the degree of ambiguity of question terms (Taylor, 1962); specificity of meaning (Saracevic, 1980; Saracevic & Kantor, 1988; Cousins, 1992); how well the user’s intent was formulated (Saracevic & Kantor, 1988); the clarity, complexity, and searchability of the question (Saracevic & Kantor, 1988); and the question’s thesaural status (Saracevic, 1980). Questions are classified according to their structural components and then subjected to experiments designed to determine the effect of query formulations on the retrieval of relevant results (Cousins, 1992; Keyes, 1996; White & Iivonen, 2001), or the effectiveness of retrieval mechanisms given a specified question with a known answer, as in the Text Retrieval Conference’s Question Answering (TREC-QA) experimental track. These studies use large sets of data in which either questions or answers can serve as controls for experimental or quasi-experimental research designs.

Despite their analog-digital differences, reference services and information retrieval share the common orientation towards the information system as the context for classifying questions. The reference and IR research classifies questions according to the system’s ability to answer them. While IR and reference question classification may

produce more effective information systems, this approach foregrounds a major limitation of the question-as-object paradigm: the functioning of the information system takes precedence over the peculiar circumstances of the individual questioner. Little regard is given as to whether the question accurately represents the questioner's cognitive information need and the contextual criteria of the search (search history, time limit, whether it is an "imposed query" (Gross, 1995), etc.). This criticism of question-answering research is found in both the reference and IR literature, in calls for question negotiation (Taylor, 1968) or query clarification (Radford & Connaway, 2006) in reference research, and for question disambiguation in information retrieval research. Research in the Text Retrieval Conference's Question-answering track (TREC-QA) has found that building better mechanisms for information retrieval is well-suited to answering "factoid" questions (akin to "ready reference" questions) that have a single clear answer, but fails when put to the test of answering complex questions with multiple and ambiguously-determined correct answers (Spärck-Jones, Robertson, & Sanderson, 2006). Spärck-Jones, Robertson, and Sanderson (2006) question the sensibility of TREC-QA's focus on unambiguous requests when the vast majority of real searches outside of testing laboratories are known to be ambiguous requests, usually of two words or less. In acknowledgment of this criticism, TREC LiveQA 2015 supplies participants with real unanswered user questions, selected from the Yahoo Answers site (TREC LiveQA 2015, n.d.). The common criticism is that there is too much attention to producing documents perceived by the system to be relevant in answering the question and too little given to the accuracy of question interpretation.

In summary, the reference and information retrieval research focuses on improving the retrieval mechanisms – whether human or automated – which mediate between questions and the selection of relevant documents or direct production of answers. The research is two-fold: it studies the components or properties of the question in order to build information systems for automated document retrieval and question answering, and it studies the properties of the information system as the respondent to the question (Table 3).

Properties of the question	<ul style="list-style-type: none"> <li>• Ambiguity/specificity of terms (Taylor, 1962; Saracevic, 1980; Saracevic &amp; Kantor, 1988; Cousins, 1992)</li> <li>• Clarity (Saracevic &amp; Kantor, 1988)</li> <li>• Complexity (Saracevic &amp; Kantor, 1988)</li> <li>• Searchability (Saracevic, 1980)</li> <li>• Thesaural status (Saracevic, 1980)</li> <li>• Subject or topic (Conner, 1927)</li> <li>• Query's conceptual presupposition (Derr, 1982; Saracevic &amp; Kantor, 1988)</li> <li>• Syntax/grammar (Saracevic, 1980; White &amp; Iiovonon, 2001; Dervin &amp; Dewdney, 1986)</li> </ul>
Properties of the information system	<ul style="list-style-type: none"> <li>• Library department (Marsteller &amp; Neuhaus, 2001)</li> <li>• Type of reference question (Cobine &amp; Mohanty, 2005)</li> <li>• Type of library resource inquired about/used to answer (DeGroot, Dorsch, Collard, &amp; Scherrer, 2005)</li> <li>• Level of skill required to answer (Warner, 2001)</li> </ul>

**Table 3. Question-as-object: Research areas**

Juxtaposing these two sides of the research, the picture that emerges is of the question in relation to the information system as respondent. Accordingly, relevance is mostly limited to subject or topic relevance and is defined as an objective property of the question, as judged by researcher-observers or subject experts. The goal is to build more efficient information systems, but in taking the question at face value, the complexity of questioners' cognitive processes of formulating and asking questions is overlooked. In response, the question research takes a cognitive turn towards a greater focus on

questioners, their unique problematic situations, and the ambiguous nature of information needs.

### **2.3 The problematic situation: Questioner-as-subject**

The conceptual shift from question-as-object to questioner-as-subject parallels the movement from the system-centered to user-centered perspective in library and information science as documented by Dervin and Nilan (1986). In contrast to the system-centered paradigm that sees users as passive receivers of information, the user-centered paradigm sees active users in individualistic situations. Talja, Tuominen, and Savolainen (2005) describe the constructivist meta-theoretical approach as similarly shifting researchers' focus from objective to subjective reality. Constructivism emphasizes the active role of the individual in making meaning from information through the processes of information needs, seeking, and use (Talja, 1997). Individuals' interactions with information are mediated by the pre-existing knowledge structures and mental models that they have of the world. Constructivist theories emphasize that "information is not a pill an individual can swallow in order to become informed, but a plastic substance that can be shaped in many ways" by the personal meanings that individuals attach to information as they make sense of reality (Talja, Tuominen, & Savolainen, 2005, p. 83).

With a turn to from the objectivity of the information system to the individual subjectivity of the questioner, the implicit context of the question becomes the individual's "problematic situation" (Schutz & Luckmann, 1974; Wersig, 1979), which exposes questioners' natural attitude or approach as insufficient in some way. The questioner comes into view as a particularized and unique being in time and space. In

this context, questions are not objective requests for information. Questions are triggered when particular individuals are faced with anomalous information (Belkin, 1978; Graesser & McMahan, 1993) or sense-making gaps (Dervin, 1992) in a specific moment in time and space. What results is called an “information need,” and questions are but imperfect reflections (Horne, 1983) or indications (Swigger, 1985) of these information needs. Horne (1983) defines the question as “an observable behavioral act *reflecting* [emphasis added] information need and proceeds from a series of cognitive processes produced by the need ‘to know.’ The need ‘to know’ is the cognitive information need which, when satisfied, creates understanding and the subsequent altering of one’s state of knowledge” (p. 5). The need “to know” is subjectively defined, with the question as the mechanism by which questioners indicate the inadequacy of their knowledge state and invite respondents to assist in remedying the inadequacy.

**2.3.1 Epistemic function.** The cognitive turn in question research shifts focus from the problems of information retrieval systems to the search for the “real” question that accurately represents the questioner’s information need. The ambiguity of language and its inability to transparently represent questioners’ cognitive information needs plays a defining role in research on questioners-as-subjects. Interpreting questions in light of existing knowledge structures and anomalous states of knowledge and sense-making gaps – in essence, trying to “see” what the information need is, inside questioners’ heads, despite what they say or do – is the core methodological problem for constructivist studies of questions. Empirical studies of questioners-as-subjects can be divided into two methodological approaches: first, the use of experiments to study questioning behaviors in relation to controlled information needs (Graesser & McMahan, 1993; Horne, 1983;

Horne, 1990; Miyake & Norman, 1979; Stavri, 1996; Wildemuth, Bliet, Friedman, Miya, 1994), and second, the study of naturalistic sites of face-to-face question behavior such as the reference interview (Taylor, 1968; White, 1989; White, 1998) or virtual question-centered communities such as online community forums (White, 2000).

Utilizing experimental methodologies, several studies have tested the relationship between the number of questions generated and the size of the information need. Miyake and Norman (1979) find that the desirable maximum number of questions occurs when people are well matched to the level of new information presented to them, suggesting that people cannot cope with material too far beyond their present knowledge. Horne (1983) is ambivalent about the relation between the number of questions and the size of the information need. She finds some evidence that the number of questions decreases as the information need is being satisfied, but also suggests that decreasing question generation does not necessarily indicate a decreasing information need.

Other studies have investigated the relationship between the mode of questioning and the state of inquiry. Horne (1983) provides empirical evidence linking the questioning mode to the state of inquiry: open questions indicate a state of information seeking, while closed questions indicate a state of information confirming, denying, or choosing (Horne, 1983). Kuhlthau's (1992; 2004) observation that questions tend to be invitational in the early stages of the search process and indicative in later stages is informative here: the "mood" of the questions is an important indicator of the nature of the information need. Gross (1995) finds that answering imposed questions involves differing information seeking stages and criteria for successful resolution than self-generated questions. Questioning strategies are also shown to relate to problem-

solving ability, with problem-solvers asking more questions overall and more open-ended information gathering questions, while non-solvers asked mostly hypothesis-testing questions, even in the early stages of problem-solving (Horne, 1990). School media specialists are particularly interested in the pedagogical implications of these findings, given the ubiquitous use of questioning as tool of critical inquiry (Farmer, 2007).

Graesser, Lang, and Horgan's (1988) semantic categorization of questions has been utilized several times by information behavioral researchers to identify the relationship between question type and the epistemic nature of the information need (Table 4) and the communicative function of the question.

<b>Semantic Categories in Question Taxonomy</b>	
<b>CATEGORY</b>	<b>GENERAL AND SPECIFIC EXAMPLES</b>
Verification	Is X true or false? <i>Is the dragon powerful?</i>
Disjunctive	Is X or Y the case? <i>Is the dragon male or female?</i>
Concept completion	Who? What? When? Where? <i>Who kidnapped the princess?</i>
Feature specification	What is the value on a variable? <i>What color is the princess' hair?</i>
Quantification	How much? How many? <i>How large is the dragon?</i>
Causal antecedent	What caused some event to occur? <i>How did the girl become frightened?</i>
Causal consequence	What happened as a consequence of X occurring? <i>What are the consequences of the dragon dying?</i>
Goal orientation	Why did an agent do some action? <i>Why did the dragon capture the princess?</i>
Enablement	What is needed for an agent to do some action? <i>How did the hero rescue the princess?</i>
Instrumental/procedural	How did the agent perform an action? <i>How did the hero rescue the princess?</i>
Expectational	Why isn't X occurring? <i>Why didn't the princess cry?</i>
Judgmental	What should an agent do? <i>What do you think I should do about my lover's insensitivity, Dr. Ruth?</i>

**Table 4. Semantic categories in question taxonomy (Graesser, Lang, & Horgan, 1988)**

By classifying large bodies of question interactions according to Graesser, Lang and Horgan's (1988) semantic categories, researchers can discern patterns in the types of

questions used and their expected functions. For instance, in a study of 610 questions asked during the course of twelve reference interviews, White (1998) finds that clients most frequently phrase questions as requests for information about a topic or for specific resources. Information specialists most often ask verification questions to affirm their interpretation of the inquirers' information needs, or judgment questions in order to solicit the opinion of the inquirers in relation to the direction of the search or to evaluate results. In the medical domain, Stavri (1996) finds that in urgent case scenarios, physicians tend to ask quantification questions – how long did the pain last? How much medicine did you take? In cases where little information is given, physicians surprisingly ask mostly verification questions, which Stavri surmises is an interpersonal tactic used with patients who are not immediately forthcoming.

Despite the findings, Stavri (1996) questions the utility of Graesser, Lang and Horgan's (1988) taxonomy, sensing that some aspect of the information need gets lost in the application of semantic function categories that would classify both of the following statements as verification questions: "Did she try to commit suicide?" and "Is the pain localized?" In contrast, Wildemuth, de Blied, Friedman, and Miya's (1994) experiment classifies medical students' questions not only by question type but also by subject content and hypothetical answer source. They find that students most often ask explanation questions about patient symptoms and appropriate treatments to the hypothetical physician, but ask identification questions about toxins and references to the hypothetical medical librarian. Classifying questions according to their semantic function in combination with the stated subject and type of answer source provides a more nuanced representation of the information need than use of the semantic function

alone. In Derr's (1984) terms, the question is comprised of both subject and query; any classification of questions that considers one without the other fails to grasp the entirety of the information need that the question represents.

Additional facets affecting the selection of relevant documents in studies from the questioner-as-subject paradigmatic approach include: the amount of research known to the inquirer (existing knowledge structure) and size of the anticipated answer (Taylor, 1962); the extent to which users' internal knowledge gave rise to the question (Saracevic & Kantor, 1988; Gross, 1995); users' estimations of the probability that public knowledge existed on the question's subject and type of application for which information was being requested (Saracevic & Kantor, 1988); nature of the information need (Horne, 1983; Kuhlthau, 1992; 2004); size of the information need (Miyake & Norman, 1979; Horne, 1983;); problem-solving ability (Horne, 1990); and the questioner's developmental stage (Farmer, 2007). Extrapolating from this list of questioner properties, the notion of relevance in the questioner-as-subject approach adheres to Talja, Tuominen, and Savolainen's (2005) characterization of relevance in the cognitive constructivist meta-theoretical approach as situational and subjective. Relevant documents must match the exact specifications of the questioner's information need, which means that it must meet the cognitive and material needs and constraints of the individual questioner as he or she stands in relation to the task, problem, or situation at hand.

**2.3.2 Interpersonal function.** A second subset of studies focuses on the interpersonal dimension of asking questions, namely, the communicative difficulties between questioners and respondents. In library science, the respondent generally takes

the form of an information intermediary, one who goes between the questioner and the universe of potentially relevant documents. Information intermediaries may be persons such as reference librarians, colleagues, family or friends; they also include information technologies such library catalogs, indexes, keyword search tools, or advanced search tools of digital libraries and databases. Studies focusing on the interaction between questioners and information intermediaries acknowledge that, in addition to the difficulty of recognizing one's own information need, there is an added dimension of having to communicate one's information need to another being or entity with its own context, set of values, and organizing principles. Asking a "particular question, in a particular way" (Kearsley, 1976, p. 355) gains an additional meaning in this context: it gives an indication of the assumptions that the questioner has about how the intermediary can or should respond. A patron approaches the reference desk or search interface with a set of preconceived notions, based on previous experience, of what constitutes "appropriate" questions and the social and technological norms that surround the interaction. When even partially incorrect, the preconceived notions can constitute a serious barrier to communication. Even when correct, they can obfuscate the information need by prioritizing the interpersonal dimension over the epistemic one.

In acknowledgment of the interpersonal dimension of questions, reference librarians are trained in question negotiation (Taylor, 1968), a working backward from the explicitly expressed question to the "ideal" question that would perfectly express the questioner's information need. Swigger (2007) makes the assertion that question negotiation is a category of research unique to LIS. The "actual" question is one that reflects the visceral need (Q1) in Taylor's (1968) model of question formation (Table 5).

Q1	The actual, but unexpressed need for information (the <i>visceral</i> need)
Q2	The conscious, within-brain description of the need (the <i>conscious</i> need)
Q3	The formal statement of the need (the <i>formalized</i> need)
Q4	The question as presented to the information system (the <i>compromised</i> need)

**Table 5. Taylor's (1968) four levels of question formation**

Information intermediaries are taught to work backwards from the compromised information need to the visceral need (Taylor, 1968), thus moving toward the questioner's "actual" information need. Questioner and respondent are on parallel tracks, attempting to balance what they individually know or do not know about the question, while simultaneously framing their communications in terms that they envision will be comprehensible by the other within the expectations of what the information system can provide.

Negotiating back to the visceral question from the expressed question requires expertise in communication strategies in equal measure to search expertise and subject knowledge. This is encompassed in the notion of the reference interview as a communicative encounter (Radford, 1999). Studies of the reference encounter suggest that librarians should use neutral questioning techniques (Dervin & Dewdney, 1985) and ask "why" questions (Dewdney & Michell, 1997) to negotiate patrons' information needs. Lynch (1978) finds that question negotiation occurs in only 35 percent of holdings transactions, 53 percent of substantive transactions, and 78 percent of "moving" transactions in which the query changes from one category to another. Studies of librarian-patron reference interaction have gone from strictly casting patrons as questioners and librarians and respondents, to a realization that both librarians and patrons ask and answer questions in the course of a communicative encounter. Radford, Connaway, Confer, Sabolsci-Boros, and Kwon (2011) find that librarians clarify questions in 74 percent of virtual reference encounters, usually in the beginning and end

stages of the encounter, and with 33 percent of clarifications utilizing open questions. Users clarify as well, at a lesser rate of 23 percent and mostly during the middle of the encounter. In terms of question subject, they find that users and librarians clarify in order to seek information about the query topic and background – search history, extent, depth, and type of resource needed. In terms of question function, users and librarians clarify in order to verify understanding and correct misunderstanding. White (1989) finds that 82.9 percent of reference librarians utilize a question-oriented approach that focuses on clarifying the question. However, she suggests that a dogged focus on question negotiation may not be as effective as a needs-oriented approach (see also Cole, Kennedy, & Carter, 1996) that focuses on clarifying the cognitive information need.

One of the major limitations of question research in the reference context is the emphasis on rational information seeking. Observing this limitation, McFadyen (1975) differentiates between informational and experiential modes of questioning. The informational mode's goal is to find specific facts and their relation to well-defined theories, while the experiential mode encourages exploration of materials in order to spark creative insights. He likens Taylor's (1968) levels of questioning to the spectrum of increasingly expressive (experiential) to designative (informational) questioning modes, with humanistic languages on the expressive end of the spectrum and scientific languages at the designative end. McFadyen (1975) recommends that reference librarians use open-ended techniques and search strategies to foster insight, a "personal *Gestalt*, rather than the analysis of a subject" (p. 9) sought by patrons with experiential inquiries. This is a different type of information intermediation, less mechanistic in nature, in which

the ultimate role of the librarians is to ask questions in order to stimulate insight, rather than to provide information or an answer.

In summary, the properties of question negotiation that have bearing on the provision of relevant documents includes: the intersubjective agreement on the "visceral need" (Taylor, 1968); presence of query clarification or question negotiation (Taylor, 1968; Lynch, 1978; Radford, Connaway, Confer et al., 2011); and mode of question negotiation (informational vs. experiential questioning) (McFadyen, 1975). These factors are reminders that questioning is a fundamentally an outward-facing phenomenon that exists between the questioner and the universe of potentially relevant documents, as mediated by additional intermediating technologies of communication including librarians, classification systems, digital libraries and print collections. Relevance is still subjective and situational, but it is influenced by the negotiation between the questioner and the intermediary.

What these studies about the epistemic and interpersonal functions of questions have in common is that they indicate various aspects of the questioner's information need, which is not easily expressible by the questioner in the first place, and then potentially clarified – but potentially further confused – by intermediaries' attempts at question negotiation. As compared to the properties of the question and of the information-system-as-respondent under the question-as-object paradigm (Table 5), research from the questioner-as-subject paradigm focuses on the properties of the questioner in relation to the problematic situation (Table 6).

Properties of the questioner	<ul style="list-style-type: none"> <li>• Amount of research known to the inquirer (Taylor, 1962)</li> <li>• Extent to which users' internal knowledge gave rise to question (Saracevic &amp; Kantor, 1988)</li> <li>• Users' estimations of the probability that public knowledge existed on the subject (Saracevic &amp; Kantor, 1988)</li> </ul>
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	<ul style="list-style-type: none"> <li>• Questioner’s problem-solving ability (Horne, 1990)</li> <li>• Developmental stage (Farmer, 2007)</li> </ul>
Properties of the problematic situation	<ul style="list-style-type: none"> <li>• Nature of the information need (Horne, 1983; Kuhlthau, 1992; 2004)</li> <li>• Size of the information need (Miyake &amp; Norman, 1979; Horne, 1983)</li> <li>• Size of anticipated answer (Taylor, 1962)</li> <li>• Type of application for which information was being requested (Saracevic &amp; Kantor, 1988)</li> </ul>

**Table 6. Questioner-as-subject: Research areas**

The questioner-as-subject perspective ceases to take the question at face-value and instead tries to work backwards from the imperfectly stated question to the “ideal” question that represents the cognitive information need that is representative of the individual questioner’s problematic situation. The implicit dimension of the question takes center stage, almost entirely eclipsing the explicitly stated question that is immediately and forever suspect. As compared to research on the question-as-object and its focus on inherent question structure and relation to the information system, questioner-as-subject research interprets questions in relation to the properties of the questioner, their existing knowledge structures and cognitive states, and of their unique problematic situation. Both areas of research assume that the primary function of the question is to communicate the questioner’s information need in order to retrieve information that can fill the need.

But how does one specify a need for what one does not know? Based on a review of experimental psychological research on question asking, Flammer (1981) proposes an outline of a psychological theory of questions that proposes the information sought by the question is fundamentally related, even dependent upon, the knowledge that the person already has. The theory’s first postulate is that explicit information-seeking questions concern information, or potential knowledge, that the questioner lacks. Postulate two is that explicit information-seeking questions presuppose some available knowledge that enables the questioner to formulate and select a “good” or “effective” question to solicit

the needed information. What the juxtaposition of the two propositions produces, he observes, is a paradox: in order to ask what one does not know, one already has to know. Questions concern information that the questioner lacks, but the formation of questions also requires the questioner to presuppose that the information exists. In other words, the ability to question assumes a certain level of pre-existing knowledge about the topic because “to ask a question of someone implies more than a need for information. It also implies a proper structure of knowledge with which to formulate the question and to interpret the response (Miyake & Norman, 1979, p. 357). As Taylor (1962) writes, “By asking a question, the inquirer imposes limits on the information acceptable as an answer. The converse of this statement is the postulate that knowing what counts as an answer is equivalent to knowing the question” (p. 393). Through interactions with information, questioners’ understanding and formulation of the question itself becomes clearer and more specific as the inquiry proceeds. Taken to the logical extreme, the question is only perfectly known and expressible at the moment that the answer is known.

From the researcher’s perspective, there is a methodological paradox that accompanies the conceptual one: the researcher can never know whether one’s interpretation of the question is accurate because it is impossible to get unmediated knowledge about cognitive states (Talja, 1997). As a result, researchers rely on measures such as user satisfaction to judge whether questions have been answered in order to compensate for the difficulty of measuring changes in knowledge structure, resolution of problematic situations, or outcomes of information acquisition. This begs the question: if the “actual” question can not be determined, or only determined in hindsight once an answer has been established, how valid is it as a theoretical concept? The search for the

illusive “actual” question privileges internal reality and individualistic information behavior over an intersubjectively constructed reality and information practice. Internal reality and external reality are only metaphorically connected, with the mental sphere opposed to social and material processes (Gergen & Wortham, 2001). In focusing on individuals’ minds, knowledge structures, and cognitive concepts, language and information become mentalized (Frohmann, 1990) and the mapping to external observable behaviors is tenuous. As a whole, the cognitive viewpoint ignores the social dimension of reality (Frohmann, 1990). The mechanisms by which individuals relate to the social world and by which mentalities relate to materialities are absent.

#### **2.4 The knowledge domain: Questioning-as-intersubjective**

One way to overcome the question paradox and to move away from the notion of the “actual” question as perfectly capturing an individual’s unique problematic situation is to place questions and question formation in a social epistemological context: question formation as an intersubjective practice rather than as an individual behavior. In response to the methodological individualism and universal model building of the cognitive viewpoint, collectivist researchers are reorienting the frame of reference to “knowledge-producing, knowledge-sharing and knowledge-consuming communities (Jacob & Shaw, 1998, p. 42). The questioning-as-intersubjective approach has its roots in what Talja, Tuominen, and Savolainen (2005) identify as the collectivist meta-theoretical approach, which they observe has much in common with the socio-cognitive viewpoint in LIS. In this approach, “knowledge” replaces “information” as the central concept. Knowledge is constructed by individuals within a socio-cultural context, and as such, the focus of study is not on individual minds but on the dialectical relationship between the

individual and the socio-cultural environment (Talja, Tuominen, & Savolainen, 2005). Knowledge is culturally situated and exists between members of a knowledge domain. If questioner-as-subject research assumes that “similar questions may have different meanings depending on who asks them” (Gelven, 2000, p. 66), questioning-as-intersubjective research presumes that different domains ask different types of questions and ask them differently. Questions are not construed primarily as indications of individuals’ problematic situations; rather, questions formulations are the products of social norms and practices of inquiry. Questioning is a shared mode of communication, delineating those who are interested in similar questions and methods of inquiry from those who, though they may be interested in the same topic, ask different questions and ask them differently.

In terms of Kearsley’s (1976) initial observation that questions convey information as well as request it, the stated question conveys information about the knowledge domain or domains in which the questioner is participating as well as their stance towards or within the domain. In Fleckian (1986) terms, members of different “thought-collectives,” for example, physicists, cabbalists, and mystics, have different “thought-styles” which results in the situation where “what is obvious for one, is nonsensical for the other” and where “a specific feeling of strangeness” characterizes attempted communications between members of different thought-collectives (p. 82). One has become a full-fledged member of a domain when thinking and speaking – and asking and answering – in the manner of the domain is second nature. The more essential a practice is to constituting the realm of sociality within the collective, the more implicit is its performance, extending even to the most basic practice of perception, as well as to

the practices of attending, classifying, remembering, assigning meaning, and reckoning the time (Zerubavel, 1999). The socio-cognitive nature of perceiving, attending, and classifying are particularly important to formulating questions. Socialization into a knowledge domain trains a member to perceive and attend to certain objects and phenomena and not others; these ontological entities are potential subjects for questions. The classification of these ontological entities is according to their features and relations, and thus determines what can be asked about them. Domains' questions, particularly when compared across domains, reveal their socio-cognitive processes of perception, attention, and classification.

The view of questioning as a socio-cultural practice is minimally present in LIS research, often as a byproduct of an ethnographic or practice-oriented perspective. In ethnographic studies of "information poor" populations such as janitors (Chatman, 1991), single mothers (Chatman, 1986), female prisoners (Chatman, 1999), and elderly women in a retirement community (Chatman, 1992), Chatman addresses the issue of why some populations do not ask questions that, from a normative perspective, would result in potentially beneficial information. What she finds is that in these "small worlds," the perceived risk of asking questions outweighs the potential benefits, such that not asking becomes a sensible behavior within the culture. Individuals in small worlds tightly control the flow of information into and out of the circumscribed world in order to maintain a sense of control, even if this means maintaining a less-than-desirable status quo. Chatman's work demonstrates that questioning, even at the basic level of asking or not asking, is a socio-cultural practice.

In those cultures that do ask, little is known about the process of enculturation by which individuals become competent practitioners of questioning within a domain. Cultural values, such as those related to questioning practices, are rarely explicitly verbalized and taught; rather, they are embodied values that require firsthand experience to learn over time. Mostly, they reside in cultural conventions and norms, which are hardly ever explicitly stated but are learned by simply enacting the practices. Weinberg (2010) illustrates how scholars of ancient Judaism accomplish this enculturation by admonishing students for asking “irrelevant” questions and enumerating the manner in which the question is irrelevant. The relevance of students’ questions is evaluated, first, according to their topicality. Tractate Avot of the Mishnah characterizes a wise man as one who “asks questions with relevance to the subject,” and the Talmud often asks, “How does the question relate to the topic?” (Weinberg, 2010, p. 1). Relevant questions are also characterized by their novelty, as when the Talmud frequently asks, “What are you adding to the discussion?” In this particular questioning tradition, questions must be topical and novel in order to be worth answering. Weinberg (2010) makes a singular contribution to the question research in LIS by noting that “in information science, the concept of relevance usually applies to answers, but in classic Jewish literature, considerations of relevance are often applied to questions” (p. 2). Asking “relevant” questions is an exercise of domain membership.

Outside of LIS, questions have been studied by researchers in education, communication, and cultural anthropology, but with a focus on what the use of questions indicates about the cultural context rather than for their epistemic purposes. Educational anthropologist Brice Heath (1982) compares the use of questions by white teachers at

school and by black families in their homes and found that questions were used with varying frequency, for different uses, and with different assumptions in the two cultural settings, leading to communicative difficulties between white teachers and black students. Cultural anthropologist Goody (1978), influenced by the work of Austin (1962) and Searle (1969), describes the performative function of questions by the Gonja people of Ghana, finding that the mode of the question (rhetorical, control, deference) is indicative of the relative status of the questioner in relation to the respondent. In communication research, Tracy and Naughton (1994) study the use of questions in academic departmental colloquia, where questions are tools used to accomplish interpersonal purposes such as supporting or challenging a presenter's identity as a knowledgeable, original, and intellectually sophisticated thinker. These studies support the questioning-as-intersubjective paradigm by demonstrating that the formation of questions, their functions, and the appropriate responses are relative to the cultural context; however, they do not attend to the epistemic function of the question to any significant degree.

The existing research that takes a social epistemological view of the question produces an understanding of the properties of the question in relation to the properties of the knowledge domain (Table 7).

Properties of the question	<ul style="list-style-type: none"> <li>• Topicality of the question (Weinberg, 2010)</li> <li>• Novelty of the question (Weinberg, 2010)</li> <li>• Scope (Weinberg, 2010)</li> <li>• Evidentiary nature (Weinberg, 2010)</li> <li>• Utility (Weinberg, 2010)</li> <li>• Performative function (Goody, 1978; Tracy and Naughton, 1994)</li> </ul>
Properties of knowledge domain	<ul style="list-style-type: none"> <li>• Whether or not to ask a question (Chatman, 1991; 1986; 1999; 1992)</li> <li>• How well the problem is defined (Saracevic &amp; Kantor, 1988)</li> <li>• Nature of the data required (empirical to theoretical) (Taylor, 1962)</li> <li>• Socio-cultural context (Brice Heath, 1982)</li> <li>• Communicative practices (Goody, 1978; Tracy and Naughton, 1994)</li> </ul>

**Table 7. Questioning-as-intersubjective: Research areas**

Compared to the cognitively-oriented criteria for relevance in the questioner-as-subject body of question research such as nature of the information need (Horne, 1983; Kuhlthau, 1992; 2004); size of the information need (Miyake & Norman, 1979; Horne, 1983); questioner's problem-solving ability (Horne, 1990), the above criteria reflect the social epistemological nature of questioning. Relevance is redefined as epistemological and domain-based, not situational and subjective. It is not sufficient for a document to fit the individual questioner's situation and subjective criteria, for in order for a knowledge claim to be justified, it must pass the social and epistemological norms of the knowledge domain. Only by referring to the domain context can one know if one's question and the ensuing answer are relevant.

In summary, the questioning-as-intersubjective paradigm overcomes the object-subject dichotomy of the question-as-object and questioner-as-subject perspectives by situating questions in the social epistemic context of a knowledge domain. In terms of Kearsley's (1976) question, of how questioners choose to ask a particular question in a particular way, the questioning-as-intersubjective perspective suggests that questioners choose to ask a particular question in a particular way relative to the knowledge domain or domains that form the context of their inquiry. Whereas language poses a major obstacle to clear communication of the "actual" question in the questioner-as-subject paradigm, in this approach language is a shared resource among domain members. The focus shifts from questioners trapped in uniquely individualized problematic situations, to the questioning practices of knowledge domains, occurring via established norms of communication. Methodologically, this allows researchers to study questions and inquiry within a specific domain context or comparatively between domains. When placed

within this social frame of inquiry, individuals' information seeking processes and the design and use of information retrieval systems are contextualized according to the appropriate domain or domains, rather than according to a one-size-fits-all model of human-information interaction.

Questions convey information as well as request it. "Thus, when a person asks a question," writes Dillon (1990), "he is communicating something in addition to the very question he asks. He communicates also what he assumes by (1) the question and (2) the asking of it – his presuppositions and presumptions" (p. 131). By placing questions in the context of domains' differing questioning practices, the question paradox is effectively inverted. Questions are transformed from a reflection of the *inability* of questioners to express their information need, to a reflection of the *ability* to engage in the work of a knowledge domain.

This dissertation explores the notion that questions are epistemic in nature and that their social context is the epistemic culture known as the knowledge domain. Knowledge domains are defined by Hjørland and Albrechtsen (1995) as "thought or discourse communities, which are parts of society's division of labor" (p. 400). Operating from the questioning-as-intersubjective paradigm, questions are recast as social epistemological tools of knowledge domain-based inquiry rather than objective representations or cognitive indications of information needs. In order to test this conception of questions, we will compare the questions found in three contrasting knowledge domains around a single topic, "memory," in order to compare different domains question formulations and what the comparisons indicate about how to answer and the domain assumptions upon which both question and answer are constructed.

## 2.5 Research goal and objectives

The goal of this dissertation is to develop a theoretical framework and methodology for the identification and characterization of domain questions, as presented in the knowledge products of inquiry. Once a theory-based methodology for identifying and characterizing domains questions is developed, the questions can be compared in order to determine the ways in which they differ by domain. This research will produce a foundation for future comparison of domains' document use for how domain definitions of relevance differ in relation to the types of questions in the domain.

The empirical objective of this study is to characterize three different domains according to the types of questions they pose about a common topic: "memory." This particular topic was chosen because of its interest to academics, professionals, and people in everyday contexts: as a means of engaging with history and the past, as a theme in literature, dance, and music; as a basic mechanism of learning; as associated with healthy aging or impairment due to neurodegenerative diseases such as Alzheimer's and Parkinson's disease; and as a material component of computer systems. The domains of neuroscience, literature, and computer engineering were chosen as the academic domains producing the most research on "memory" and for encompassing several distinct contexts in which memory is of interest.

The empirical objective is achieved via a comparative analysis of domains' question formulations according to content and form. Comparative analysis is an underutilized methodology in LIS, corresponding to a dearth in the depth of knowledge of the formal dimensions of phenomena of human-information and human-document interaction. This may be partially explained by the historical focus on subject expertise

in LIS, which has produced many studies of domain-specific behavior and practices, but little knowledge of the structural aspects of humans' interaction with documents. While there is increasing interest in social epistemology and socially informed theoretical perspectives as frameworks for understanding information- and document-related practices, the methodological approaches to empirical study of these social phenomena are still developing. The comparative methodology utilized herein is presented in the social epistemologically informed vein of domain analysis, but with a central interest in the phenomenon of questioning across domains rather than an in-depth understanding of any single domain.

## **2.6 Research questions, general**

The central research question is: How do knowledge domains' question formulations about a common topic compare and what do the comparisons convey about the answers that follow and the assumptions that precede the questions? In order to address the central question, the following general research questions will organize inquiry into three stages of analysis:

- I. What questions do the neuroscience, literature, and computer engineering domains formulate about "memory"?
- II. How do the domains' question formulations compare?
- III. What information do the comparisons between domains' question formulations convey about the answers that follow and the assumptions that precede the questions?

The first question requires the development of methods for identifying knowledge domains' question formulations from the knowledge products of inquiry. The second

question requires categorization of the question formulations in order to produce question profiles of each domain, which can then be compared in order to make visible the distinct perspectives on producing knowledge about “memory” between and among the knowledge domains. Finally, the third question directs a formal gaze at the phenomenon of questioning by consideration of the structural relations between questions, answers, and assumptions across the three domains. What results is increased knowledge of domains’ question formulations, research on “memory” in three domains, and the structure of questions as a tool of inquiry.

## CHAPTER 3: THEORETICAL FRAMEWORK

If we were able to indicate the set of questions to which a given discipline tries to give answers, then we would have a precise image of this discipline. In questions, we may express everything that we know, what we do not know and what we want to know at a given moment. (Brožek, 2011, p. 266)

### 3.1 Overview

While library and information science has long been interested in the questions with which patrons and users approach information systems, research in this area has been stalled by what has been identified by psychologist Flammer (1981) as a paradox of question asking: in order to ask questions, one already has to know what can be known. Questions concern information that the questioner lacks but also presuppose some available knowledge (Flammer, 1981). Most of the seminal models of information seeking reflect the tension of this paradox, which requires questioners to articulate what it is that they do not know in terms of what is known, whether the unknown takes the form of an “anomalous state of knowledge” (Belkin, 1978), “problematic situation” (Wersig, 1979), or sense-making gap (Dervin, 1992). The turn in library and information science research from the information transfer model to a cognitive meta-theoretical perspective shifted researchers’ attentions from objective to subjective reality, in which individuals’ interactions with information are mediated by pre-existing knowledge structures and mental models of the world (Talja, Tuominen, & Savolainen, 2006). In turn, the question is recast as an observable behavioral act that reflects information need (Horne, 1983) and requires negotiation (Taylor, 1968), rather than a transparent request for information. But by focusing on individuals’ minds, knowledge structures, and cognitive concepts, language and information become mentalized and the social dimension of reality is

ignored (Frohmann, 1990). The present investigation seeks a way out of the question paradox by presuming that knowledge is a social phenomenon and that a reconceptualization of questions according to a social framework of reality is both a theoretically and pragmatically fruitful endeavor.

In conducting a social epistemological investigation of questions, two questions arise. First, what is the relevant context for a social conception of the question? Domain analysis is employed for its characterization of the “knowledge-producing, knowledge-sharing and knowledge-consuming communities (Jacob & Shaw, 1998, p. 42)” known as “knowledge domains” (or simply, “domains”) that are the social epistemological context for question asking and answering, among many other information practices and phenomena. Hjørland (2010) proposes domain analysis as a meta-theoretical framework for library and information science (LIS), one that proposes “domains,” rather than individual cognitive structures, as the primary object of study. Domain analysis offers a conceptualization of the domain as a social unit of knowledge production and the foundational context for all knowledge practices, including the most fundamental practice of inquiry.

Second, how should the question be conceptualized in relation to the social units of knowledge production? A logical philosophical approach allows for the formal elements of questions and answers to be identified and compared across vastly diverse domains. Brožek’s (2011) erotetics, or theory of questions, provides a philosophical conception of questions according to their logical structure and communicative function. This conception offers a theoretical perspective with which to approach the documentary

products of domain knowledge production when seeking to identify the questions and answers represented therein, even as their linguistic expressions differ.

The theoretical framework developed in this chapter is directed towards definition of the domain analytic and erotetic concepts that are needed for the current investigation of what questions indicate about domain assumptions related to knowledge production, as guided by the specific research questions stated at the end of the chapter. Erotetic theory provides a theoretical conception of the question as an epistemological tool, displaying function and form, while domain analysis provides a theoretical conception of the knowledge domain as the context of questions and inquiry. By comparing domains questions according to logical structure and communicative functions, the ability of question formulations to convey information about the answers that follow and the assumptions that precede the question begins to emerge.

## **3.2 Domain analysis**

**3.2.1 Knowledge domains.** First articulated by Hjørland and Albrechtsen (1995) as a sociological-epistemological paradigm for library and information science, domain analysis is a response to the methodological individualism of the cognitive viewpoint in information science, which views individuals as rational information processors and frames their information-related behaviors and practices as products of isolated user needs and individuals' abilities and constraints. In contrast, domain analysis posits that cognition is fundamentally social, as individuals' perceptions and thoughts are shaped through the language use and material practices of the knowledge domain. Information should be understood not in terms of individual cognitive structures but in the context of knowledge-domains as thought communities such as scientific disciplines or scholarly

fields, or discourse communities such as those connected to a political party, a religion, a trade, or a hobby (Hjørland & Albrechtsen, 1995; Hjørland, 2010). Knowledge domains are the primary context for the production and justification of knowledge.

Hjørland (2010) notes that though domain analysis takes the domain as its primary focus, it also has a view on individual cognition that can be described as socio-cognitive and related to American pragmatists such as John Dewey and Russian historical-cultural psychologists such as L. S. Vygotsky. When considering individuals, they are considered from the socio-cognitive viewpoint, not as “users in general” but as belonging to different cultures, to different social structures, and to different domains of knowledge. Information producers, intermediaries, and users are more or less connected in communities that share common languages, genres, and other typified communication practices. There are different ‘semantic distances’ between the agents. (Hjørland, 2010, p. 1652)

In other words, reality cannot be understood by “the unprepared and isolated subject,” but rather requires “the knowing subject, who is formed by history and culture, including the concrete development in specific knowledge-domains” (Hjørland & Albrechtsen, 1995, p. 408).

### **3.2.2 Preceding and related social approaches in LIS.**

Hjørland and Albrechtsen (1995) identify the explicit and latent contributors to the formulation of domain analysis as: Patrick Wilson’s (1993) identification of specialties as the relevant unit of study; Taylor’s (1991) Information Use Environments; Saracevic’s (1975) subject knowledge view of relevance; and Froehlich’s (1989, 1994) view of social epistemology as the foundation for information science. What these studies have

in common is that (1) they use comparative methods to identify patterns between groups, and (2) they attend to the epistemological nature of the differences between knowledge domains. Domain analysis thus applies theoretical and methodological rigor to what information scientists and documentalists have traditionally done as a matter of training and intuition: organize documents for access by domain members according to their cultural practices and epistemic norms. Domain analysis re-contextualizes user studies from a universal and cognitivist viewpoint of information behavior to its domain-specific contexts, providing a framework within which findings from individual user studies can be related to one another rather than standing in isolation. It is thus simultaneously a return to the traditional principles of documentation and a unifying way forward for library and information science. It hearkens back to the historical development of information science by subject specialists, while also providing a theoretical view of knowledge phenomena and integrating sub-disciplines such as bibliometrics, document representation, document retrieval, information seeking (Hjørland, 2010).

**3.2.3 Domain analysis as general foundation for LIS.** Hjørland (2002a) claims that the epistemological approach of domain analysis, though difficult and even problematic due to its epistemological dimension, may be the only general foundation that is possible for library and information science to establish, as epistemology forms an interdisciplinary foundation for general theories of knowledge-related phenomena. Library and information science professionals and scholars, he suggests, should not compete for status with the subject experts whose intellectual products, processes, and structures form the content of a unique domain. Domain analysis seeks to move information science beyond the organization of the subject matter found in information

objects such as textual documents and recorded images, to the study of their production and organization. Information scientists should be experts in the information resources of the subject fields (Hjørland, 2010): the production, organization, and means of accessing the knowledge products of the domain, rather than the subject content of the domain. Through the study of individual domains and domains in relation to each other, information specialists will be able to “formulate ‘general’ theoretical principles” (Hjørland, 2010, p. 1649) about people and their interactions with information or the phenomena that arise from the interaction between people and information. This interest in the forms of human-information phenomena across domains, in addition to the subject content of individual domains, can be seen as an antidote to what Wilson (1994) sees as the failure of user studies to produce much valuable knowledge about how and why people interact with information.

Hjørland (2010) identifies a number of areas as belonging distinctly to an information science that is grounded in the sociological-epistemological perspective of domain analysis: systems of communication, document types, genres, special languages, special functions; who the knowledge producers are, who the intermediate actors are, who the users are, and how all the agents, institutions, and services are connected in social systems; relevance criteria/quality criteria for selecting documents, for indexing documents, and for retrieving documents; and how the field is structured, or, should be structured. Knowledge of these domain-relevant areas would distinguish information professionals and scholars from subject specialists in a manner that supports Bates’ (1999) assertion that LIS is a meta-discipline that is orthogonal to conventional subject-based academic disciplines.

**3.2.4 Domain dimensions.** Hjørland and Hartel (2003b) have broadly described knowledge domains as having three main dimensions: ontological, epistemological, and sociological. Each dimension will be discussed briefly before considering the implications for characterizing domains based on the questions that they pose.

**3.2.4.1 *Ontological dimension.*** Of the three dimensions, the ontological dimension is the most fundamental in defining a knowledge domain. Ontological theories describe the nature of reality, or what sorts of things exist in the world.

A scientific discipline is normally defined by its object, for example, botany by plants, zoology by animals, psychology by minds and behaviors, history by the past, theology by God, etc. A theory of what objects exist in the world is called ‘an ontological theory.’ Domains are normally defined by ontological theories (at least implicitly). (Hjørland, 2010, p. 1650)

The “objects” that exist in any given domain may be material objects, properties, events, phenomena, processes, structures, or relations, among others. It is essential to understand ontological theories when studying domains because ontology determines the possible objects of study. Ontological concepts form the basis of systems of classification. LIS has historically focused heavily on the ontological dimension of knowledge domains via research about and practices of classification and indexing as the basic methods by which documents are organized for access and retrieval. As domains’ understanding increases and the view of reality changes, their ontological theories change (Hjørland, 2010), which should be reflected in the classification systems and practices of indexing.

**3.2.4.2 *Epistemological dimension.*** If ontology can be characterized as a theory of the objects that can be known, epistemology is the study of the nature, sources, and

limits of knowledge, or how one can know what one knows. The central epistemological concern is with justification, what it means for a knowledge claim to be justified and what makes justified beliefs justifiable. Epistemology is a fundamental concern of domain analysis because knowledge domains' beliefs regarding the nature, sources, and limits of knowledge determine the manner in which they produce and circulate knowledge. As such, it is fundamentally related to most library and information science concepts such as relevance (Hjørland, 2002b), classification systems, genres, documents (Hjørland & Hartel, 2003a), cognitive authority (Wilson, 1983), expertise, and credibility. Hjørland (2002b, p. 268) writes, "The cognitive view tends to psychologize the epistemological issues (to study knowledge by studying the individual), but what is needed is the socio-cognitive view, which tends to epistemologize psychological issues (to see individual knowledge in a historical, cultural, and social perspective)." From the viewpoint of the social epistemological position, domain analytic scholars can understand the why behind the how of the inquiry process. Different epistemological stances are differentiated based upon the relation between the knower and the known.

Epistemological dimensions may be uncovered by studying domains singly as they change over time, or comparatively at a single point in time, as in the use of bibliometrics to visualize the relationships between multiple domains (Hjørland & Hartel, 2003b). The operative commonality between these methodological approaches is comparison across time or space: the epistemological dimension is revealed in between knowledge domains, or a single domain across different points in time. The methodology employed in this dissertation is of the former kind: comparison of multiple domains in

relation to a common topic. A justification of the comparative approach will be detailed in Chapter Four, Research Methodology and Design.

**3.2.4.3 Sociological dimension.** The sociological dimension of domain analysis distinguishes it from currently dominant cognitive approaches in human information behavior, hearkening back to the traditional focus of documentalists on organizing information for specific user groups, but from a meta-perspective of knowledge domains as the basic context for human-information interaction. Hjørland and Hartel (2003b, p. 242) broadly describe the sociological dimension as being “about groups of people working with some objects by applying some approaches.” This broad characterization allows knowledge domains to be viewed as a purely analytic construct as well as a pragmatic one, in the sense of knowledge domains as “parts of society’s division of labor” (Hjørland & Albrechtsen, 1995). Hjørland (2000) asserts that epistemological positions such as empiricism, rationalism, historicism, and pragmatism, should be considered as the most generalizable explanatory models of relevance and information-seeking patterns, which leads Fry and Talja (2004) to criticize domain analysis as privileging epistemological considerations over social factors such as reputation building and reward systems within specialties or disciplines, which they assert are equally influential in shaping scholarly communication structures. Fry and Talja’s (2004) study of intellectual fields finds that information practices in the digital realm are shaped by the dynamic interrelationship of social and epistemic characteristics that constitute the culture of the intellectual field.

Here we see two different conceptions of the “social” in social epistemology, differentiated by the degree to which the “social” exists apart from the “epistemic.” Fry

and Talja's (2004) conception of the social is a mediating influence or force on the epistemic process of inquiry, as, for instance, when researchers formulate questions based on available funding, departmental resources, publishing or job opportunities. Hjørland's (2000) view melds the social and epistemic completely, concerned as it is with the social foundation of the epistemic processes of inquiry, as belonging to thought or discourse communities, rather than the ways in which social pressures mediate or moderate individual inclinations. The social epistemic view of domains is exemplified by Knorr Cetina's (1999) research on epistemic cultures, which directs researchers' attention to the social nature of knowledge production as evidenced in the comparison between the empirical, technological, and social machineries of high-energy physics and laboratory biology. These two conceptions of the sociological dimension occupy different positions along the spectrum of tacit performance of domain membership: in the previous case, behavior and thought are consciously adjusted to the norms and practices of the domain while in the latter, the behaviors and thoughts are sub-consciously adherent to the domain.

**3.2.5 Defining domains.** Researchers working from the domain analytic viewpoint have proposed many different ways of identifying the domain as the unit of analysis. Hjørland and Albrechtsen's (1995) initial description of domains as disciplines, trades, discourse communities, working groups, or thought communities indicates that the concept of a domain is flexible and ultimately depends upon what is most empirically useful. Some other examples of domains include: scientific discipline or scholarly field, or a discourse community connected to a political party, religion, trade, or hobby (Hjørland, 2010, p. 1650).

While single-domain studies tend to rely solely on the ontological dimension and to define domains by the subjects and topics that comprise the domain's boundaries of knowledge production, comparative studies bring attention to the epistemological and sociological differences between domains as well as the obvious ontological differences. There are several well-known typologies dealing specifically with academic domains, such as Becher's (1989) characterization of academic tribes and territories in which the subject content is related to the cognitive and social characteristics of those in the discipline, or Biglan's (1973) typology of academic disciplines according to the axes of hard-soft, pure-applied, and life-nonlife. In LIS, Talja and Maula (2003) choose domains for empirical comparison that differ structurally in terms of size, degree of scatter, and relevance criteria. Fry (2004) takes the intellectual field as the structural and communicative unit of analysis, but moves between perspectives of the scholarly community, the intellectual field, and the discipline as relevant and interrelated social configurations as embodied in teaching programs, journals, conferences, and funding agencies. Fry and Talja (2004) and Talja, Vakkari, Fry, and Wouters (2007) use Whitley's (1984) theory of the social and intellectual organization of the sciences, which integrates the epistemic consideration of task uncertainty and social consideration of mutual dependence to define domains as specialist fields. Tennis (2003) offers a structural definition of domain, operationalizing domain along two axes: areas of modulation (scope) and degrees of specialization (intension/extension), in order that knowledge produced by domain analysts can be transferable. Informed by her focus on interdisciplinary information seeking, Palmer (1999a) questions the utility in these attempts to forge consensus on a definition of domains, suggesting that domains are

continually changing in size and shape as they are constructed and modified by their participants. She suggests, based on her own empirical study of interdisciplinary information seeking (Palmer, 1999b), that domains are most helpfully defined in relation to the particular types of research problems being addressed rather than the subject area of the researcher's training.

**3.2.6. Domains as the context for questions.** This dissertation compares three domains' question formulations on a common topic, "memory," in order to explore the nature of questions as tools of domain-based inquiry. Becher (1979) asserts that academic disciplines are distinguishable by the questions they ask. This dissertation proposes that knowledge domains, of which academic disciplines are one type, are distinguishable by the questions they ask. Particularly in the realm of scholarly inquiry, questions should be precisely formulated in such a manner that they reflect, both explicitly and implicitly, the ontological, epistemological, and social dimensions of the domains from which they emerge. In contrast with the cognitive viewpoint, which views question formation as an individual cognitive process reflecting the mental state and knowledge structures of the questioner, a social epistemological perspective such as is offered by domain analysis views question formulations as domain products and tools of inquiry.

The importance of understanding the domain context of the question is demonstrated by the following example. In a review of the topic of social epistemology in LIS, Fallis (2006) offers the following analysis of a potential intelligence test question as an argument for the importance of a social constructionist understanding of knowledge:

There are five birds sitting on a fence. You shoot one of these birds. How many birds are left on the fence?" Some people (and cultures) will say four because five minus one is four; others will say none because when you shoot one, the rest will be scared off and fly away. But really, these are two different questions with different answers: (1) What is five minus one? Four; and (2) What happens when you shoot at birds? They fly away. (Fallis, 2006, p. 491)

Here we see that the answer formulated in reply to the question depends entirely upon the domain context. The difference between the two answers can be attributed to the differing domain contexts, of groups of like-minded people, or cultures. The domain contexts can also be defined in terms of academic disciplines. The first question and answer (What is five minus one? Four.), takes as its domain context the discipline of mathematics, in which the bird scenario illustrates the mathematical principle of subtraction. The second question and answer (What happens when you shoot at birds? They fly away), may take as its domain context the discipline of zoology, or the subfield of etiology, the study of animal behavior, in which the question directs the respondent towards observation of how the animals behave in response to a stimulus. Different academic domains will approach the same data, situation, or topic with different assumptions about what is of interest and what can be known, which manifest in the formulation of distinct questions and the subsequent production of equally distinct answers.

Whereas language can be a barrier to communication across domain boundaries, it is a shared resource within domains. Fallis's (2006) example demonstrates that the more precisely the question is worded in accordance with the habitual language use of the

domain, the easier it is to identify the questioner's domain, to orient inquiry in accordance with domain norms, and to communicate the domain-appropriate answer. This is similar to Taylor's (1968) injunction to negotiate back to the "visceral" information need from the "compromised need," but shifts the contextual frame from the individual questioner to the knowledge domain. The "ideal" question is the one that most precisely articulates the individual's indeterminate situation in terms that comply with domain norms and practices. Fallis's (2006) example suggests that different domains ask different questions, and that understanding the assumptions of the domain context is necessary for formulating an appropriate reply. By re-conceptualizing the "ideal" question with reference not to the individual's mental model but to domains' question formulations, information intermediaries can negotiate the formation of more accurate questions.

Having established the theoretical rationale for the knowledge domain as the context for questioning, the following section outlines the theoretical framework for approaching questions as social epistemological tools of inquiry and the problem of implicit questions in scholarly inquiry.

### **3.3 Erotetic Theory**

The logical philosophical approach offers a conceptualization of questions that sheds light on the central dilemma in the study of questions in inquiry, particularly as it pertains to the knowledge products of inquiry: how can the questions that drive inquiry be identified? Rarely do the knowledge products of inquiry state the questions that drive inquiry in direct interrogative form. The nature of the domain as a site for knowledge production is that the things that are most fundamental to the domain need not be stated;

what is stated are those things that require validation or justification. Accordingly, the questions that drive inquiry remain implicit while the knowledge claims produced by the question-driven inquiry are explicitly stated as declarative expressions of findings, results, or arguments. Questions are fundamental to inquiry but, to varying degrees depending on the practices of the domain, they are largely unstated. The tension between the import of the question in organizing inquiry and its tacit status as a marker of domain competence makes questions a difficult subject for empirical research.

The erotetic logical approach enables the development of a method for identifying the implicit questions that organize inquiry from the knowledge products of the inquiry in diverse domains. Brožek (2011) proposes a general theory of questions consisting of “a semiotic analysis of questions and answers, their components, their grammatico-logical form, and the relations between elements of erotetic situation” (p. 17), or the types, structures and functions of question-related objects. The nature of the application of erotetic theory to the current study of the social epistemological nature of questions relies upon the ability of logical philosophical analysis to be applied equally to questions spoken by an individual as to those “spoken,” metaphorically, by a collective such as a knowledge domain. Furner (2012) notes that there is an obvious analogy to be made between the logical philosophical analysis of a sentence as a sequence of words, and of a document, as a sequence or aggregation of sentences. This is, in fact, the lens through which erotetic theory is here applied, to the knowledge products of inquiry (dissertation abstracts) as sequences or aggregations of sentences. The knowledge products are analyzed as multi-sentence expressions of the question that motivates the research and the answer produced by it. A theoretical conceptualization of the question from the logical

philosophical approach provides guidelines for the identification of the implicit questions driving scholarly inquiry from the knowledge products of research according to their communicative function and logical structure.

**3.3.1 Communicative function of questions.** Brožek (2011) defines communicative functions as connecting classes of expressions to a typical, abstracted type of experience, which allows a sentence to be meaningful and comprehensible to others. The expressions in class *K* are distinguished by the structural properties of the expression and the psychological properties it attributes to the speaker. Questions, Brožek (2011) asserts, are a special class of expressions with a distinct communicative function: “Questions are expressions suitable for communicating experiences consisting of gapped cognitive pictures of the world and the will to fill gaps in them” (p. 53). Structurally, questions are usually marked by a question mark or its spoken counterpart, rising intonation, as well as an inverted word order. Psychologically, the experience being communicated by questions can be described as a confluence of three factors: the cognitive, incognitive, and volitional (Brožek, 2011).

First, the cognitive factor of the experience expressed by the question is the conviction that there exists an adequate picture of the situation (Brožek, 2011), what Dewey (1938) would call the “determinate situation.” When Flammer (1981) observes that one must know enough to ask, he is referring to this cognitive factor: the questioner must “know,” in the sense of believing, that there is an adequate picture of the situation. Without the conviction that there exists an adequate picture of the situation, the questioner has no grounds for posing the question. Second, by posing a question, the questioner indicates a realized ignorance or gap in the picture (incognitive factor)

(Brożek, 2011). This realized ignorance is what motivates inquiry towards the filling of the gap. The notion of information seeking behavior as resulting from perceived gaps in situations is already present in LIS, most notably in Dervin's (1992) Sense-Making Theory, in which information seekers experience a gap in a situation that requires the use of information, in the form of ideas, attitudes, beliefs, emotions, intuitions, memories, narratives, etc., to bridge the gap in reality and continue on in their sense-making. Emphasis on the formulation and expression of this cognitive gap in a manner that comprehensibly solicits the needed information constitutes a significant focus of the question research in LIS.

The third psychological factor of questions is the volitional factor, the will to fill the gap or to complete the picture of the situation (Brożek, 2011). In Mackay's (1960) terms, questions are both indication – in erotetic terms, of the conviction that there exists an adequate picture of the situation and that there is a gap in the questioner's picture – and invitation to a respondent to fill in the gap. The response may be sought in the testimony of others or by recalling what one already knows (Hookway, 2008), but without the invitation to respond, the expression is not a question.

The combination of cognitive, incognitive, and volitional psychological factors distinguishes questions from declarative and imperative expressions as having a distinct communicative function. Consider the difference between (1) and (2).

- (1) Are you enjoying this book?
- (2) I want to know whether you are enjoying this book.

Sentence (1) expresses the speaker's experience of a gapped cognitive situation, not knowing whether or not the respondent enjoys classical music, with a will to fill in the

gap, expressed as an invitation to respond. In addition to the psychological properties attributed to the speaker, the expression is structurally marked by a question mark and inverted word order. Sentence (2) is a declarative expression, defined by Brožek (2011) as a sentence that says something about the epistemic states and acts (convictions judgments, doubts, assumptions, etc.) of the sender. It expresses the same cognitive gap as in (1), but without a will or invitation to fill it. Not all declarative expressions express a cognitive gap, but those that do, as (2) does, are not technically questions as they lack the volitional factor. However, the type of declarative expression in (2) is colloquially considered a passive or indirect form of question.

Sentence (3) is in the class of orders, or imperative sentences, which have the volitional factor, but do not express a cognitive gap.

(3) You will enjoy this book.

Order expressions are used to communicate the will to realize one's picture of reality, to make reality correspond to the picture that one has of a situation (Brožek, 2011), in this case, a will to make the questioner's cognitive picture (that the respondent enjoy the book) correspond to reality. The comparison between the three types of expressions demonstrates that questions are differentiated as a unique expression type by having all three psychological factors: the cognitive and incognitive, which produce a gapped, picture of reality, and the volitional, a will to fill in the gap (Brožek, 2011). Questions are indication and invitation (Mackay, 1960).

**3.3.2 Logical structures of questions.** Within the class of expressions known as questions, there are two basic logical structures: complete and hypothetical (Brožek, 2011). The structural types are differentiated by the experiences that motivate the asking

of the question. Question (4) is a *completive* question from one of the literature dissertation abstracts in the sample, which functions to communicate the experience of a cognitive gap and the will to fill it:

(4) How are memory and history embedded in images of the built environment (L11)?

Completive questions have three explicit parts: a question particle (who, what, when, where, why, how) and question mark, which together constitute the “query,” and the “remainder” that defines the unknown (Brožek, 2011). This conception converges with Derr’s (1984) conception of question structure as having two parts: the *subject*, the object in the world<sup>4</sup> about which an epistemic determination is being made, and *query*, the type of epistemic determination. In colloquial terms, completive questions are open-ended questions. They identify a gapped cognitive picture and issue an invitation for respondents to answer. The gapped picture in (4) asks how – by what manner, way, or means – memory and history are embedded in images of the built environment.

A *hypothetive* question communicates the experience not only of the will to fill a gapped picture of a situation, but a hypothesis of how to fill the gap (Brožek, 2011).

Statement (5) is a hypothesis question from the sample of neuroscience dissertation abstracts:

(5) Is long-term memory distorted by information erroneously retrieved from episodic memory (N8)?

By posing (5), the questioner expects the respondent to verify the hypothesis. The hypothetive question, a type of closed-ended question, is seeking its own verification.

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<sup>4</sup> Brožek (2011) would describe it as a “picture of the world” rather than “object in the world,” which is preferable for its broadness in including non-object subjects.

Hypothetive questions are constructed by inversion of the subject and verb<sup>5</sup> (“Stress impairs memory updating” inverts to “Is memory updating impaired by stress?”), unless logically structured as whether-questions, as in (6):

- (6) Whether long-term memory is distorted by information erroneously retrieved from episodic memory. (N8)

Structurally, hypothetive questions are composed of two parts: a question signal, such as inversion plus a question mark, and a hypothesis of how to fill the cognitive gap. For both (5) and (6), the hypothesis is that long-term memory is distorted by information erroneously retrieved from episodic memory. The question signal in (5) is inversion plus a question mark, while in (6) it is the whether- question indicative.

Selective questions pose a special case of hypothetive questions in which multiple hypotheses are being put forth to fill the gap of the picture of the situation. Consider the question in (7):

- (7) Which is most effective for the study of the expression and extinction of conditioned fear memory: foot shock, immobilization or predator exposure, alone and in combination?

In this case, the hypotheses to fill the gap of the picture of the situation are indicated by the methods that have been chosen for testing: foot shock, immobilization, and predator exposure, either alone or in combination. In effect, (7) proposes six hypotheses to fill the

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<sup>5</sup> At least, they are in English. Brożek (2011, p. 131) notes that in other languages such as Polish, inversion is not needed because there is a specialized operator ‘czy’ that occurs at the beginning of hypothetive questions.

gap of the picture of the best method for the study of fear extinction using mice<sup>6</sup> and expects to verify that one of the six can be identified as most effective.

**3.3.3 Scientific domains' questions.** Brożek (2011) employs the term “scientific discipline” to describe the subset of knowledge domains that engage in scholarly inquiry, rather than the narrower set of scholarly domains that employ the scientific method. She identifies scientific disciplines as composed of:

- Problems - the set of questions to which representatives of a given discipline try to find an answer or to which an answer is already given in this discipline;
- Methodological directives – rules of how to resolve problems; how to find answers to scientific questions; and
- Theories – ordered sets of answers to scientific questions.

Brożek’s “scientific disciplines,” or what this dissertation terms “scholarly knowledge domains,” should be reflected in the questions they ask and how they answer them.

According to Brożek’s (2011) definition of a question as an expression of the will to fill a gap in a picture of a situation, the question arises as to who is the subject whose will is being expressed in scholarly questions. Scholarly questions differ slightly from interpersonal questions by the definition of the “subject” exerting volition through the question. The will to fill in the gap in the picture of reality ultimately belongs not to the individual questioner, but to the scholarly community or knowledge domain on behalf of which the questioner is conducting the inquiry. The questioner expresses the scholarly community’s will to fill in a gap in the picture of the situation, or what Dewey (1938)

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<sup>6</sup> The six hypotheses ask, which is more effective: foot shock or immobilization; foot shock or predator exposure; immobilization or predator exposure; foot shock and immobilization or predator exposure; foot shock and predator exposure or immobilization; and immobilization and predator exposure or foot shock?

refers to as determination of an indeterminate situation, as defined by their disciplinary lens. A precisely formulated domain question expresses “everything that we know, what we do not know and what we want to know at a given moment” such that it is semiotico-logically correct, properly posed, and resolvable according to domain norms (Brožek, 2011, p, 266). A domain’s indeterminate picture of a situation and the definition of the gap in relation to the situation, even if a situation shared with other domains, will differ according to the methodological directives and theories of the discipline. The implication is that different domains should ask different questions.

Scholarly questioning also differs from everyday question situations according to the receiver and respondent of the question (Brožek, 2011). Whereas in everyday questioning the receiver of the question is generally another person who replies with a verbal response, scientific questioning is received by the part of reality that is being examined. Natural scientific inquiry is a controlled and testable approach to studying natural reality, while humanistic inquiry studies the reality of products of human activity (Brožek, 2011). The respondent to the scholarly questions is the reality that is being studied, whether nature or the products of human activity, as spoken for by the inquirer. Here, Brožek points out, nature and the products of human activities are the “respondents” only in a metaphorical sense; in fact, the scientist is responding to herself by interpreting the data through the lens of the adequately formulated question. This is designated as “the solitary case” of questioning (Hookway, 2008), where the questioner and respondent are one and the same.

**3.3.4 Answers.** One of the capacities one must possess to produce knowledge, in addition to the capacity for formulating questions, is an ability to recognize whether

something is an answer to a given question (Hookway, 2008). The structure of the question indicates what counts as a correct answer: “it is an answer that uniquely picks out the member of the universe of interrogative quantification who satisfies the attributive presupposition of the question” (Hookway, 2008, p. 7). The logical structure of the completive question in (4) identifies the universe of possible correct answers: “how” indicates that the answer should demonstrate the manner in which something happens or is achieved, while the rest of the question identifies what it is that is happening: the references to Fénelon’s name are reflecting and affecting cultural memory. In Dewey’s (1938) terms, the manner in which the situation is indeterminate indicates the determination that needs to be made. The answer to (4), which is presented as the thesis statement, is:

- (8) Fénelon's name appears hundreds of times in the literature of the long nineteenth century, and the context surrounding his name offers a view of the posterity of Fénelon, which contradicts what is available through an investigation of biographies and academic studies of his theological and literary work alone. I show through my dissertation that memory is not only a reconstructive process, but a referential one. (N8)

The answer shows how the changing nature of references to Fénelon’s name marks the cultural shift in the treatment of memory, from being solely referential, as found in biographies and academic treatments, to reconstructive, as called upon in literary texts as a vehicle for the culture to deal with the past.

In (5), the logical structure of a hypothetive question constricts the possible answers to “yes” – long-term memory is distorted by information erroneously retrieved from episodic memory – or “no.” The answer to (5) is an indirect “yes”:

- (9) Retrieved information is preferentially stored and accessed in memory, which can have both beneficial and impairing effects on long-term memory (N8).

Brožek (2011) defines answers, in the traditional logical sense, as “sentence-types, being in certain syntactico-semantic relations to [this] question” (p. 207), while emphasizing the communicative functions of the answer sentences. This communicative function of answers is what differentiates direct answers from indirect answers. Direct answers communicate how to fill the gap in the picture of the situation, while indirect answers do not directly fill the gap, but provide information that enables the questioner to fill it. The answer in (9) provides information that enables the questioner to answer the question in (5) with a yes – long-term memory is distorted by erroneously retrieved memory. Other types of answers, as defined by their communicative senses, are partial answers (only partially fills the gap), limiting answers (limits the scope of the gap), correcting answers (corrects the picture of the situation), modifying answers (modifies the picture of the situation), and exhaustive answers (provides all possible accurate ways to fill the gap).

How does a respondent know which types of answers are acceptable? Again, familiarity with the domain context is needed in order to understand what type of answer the question requires, just as domain knowledge is needed to determine the proper emphasis of a question. Hookway (2008) identifies the role of context in answering questions as well as understanding them. For any given correct answer, he asserts, there are multiple ways of presenting the answer, some of which may meet the questioner’s

needs, while others do not, or some better than others. Answering questions requires the respondent to know what counts as a correct answer, and what is the best manner of its presentation. In the context of the literature domain, the respondent knows that the question in (4), of how the references to Fénelon's name are reflecting and affecting cultural memory, can be answered by asserting that memory is both referential and reconstructive. Furthermore, relevant answers are those that respond to the "conversational context" (Hookway, 2008, p. 10) by attributing "salience" to some aspects of the answer. In the "conversational context" of literature, the relevant answer is that memory is "not *only* referential, but reconstructive in nature (emphasis mine)" (L9). This indicates that the questioner presumes that the domain largely views memory as referential and that the additional property of being reconstructive in nature adds a new dimension to the domain discourse.<sup>7</sup>

**3.3.6 Assumptions.** Every question is based on some convictions about the gapped picture of the situation from which the question arises, which constitute the background of a given question (Brožek, 2011). Brožek (2011) identifies these convictions, the assumptions of the question and the presuppositions that analytically or semantically follow from the assumption, as comprising the cognitive content of the question. The assumptions and presuppositions can be reconstructed purely on the basis of the structural form of a question. For example, the completive question (4) ("How are memory and history embedded in images of the built environment?") can be said to express the assumption that memory and history are embedded in images of the built

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<sup>7</sup> Whether the questioner's presumption about the domain's state of knowledge regarding the properties of memory is correct does not affect the logical interpretation of what constitutes a relevant answer.

environment, as well as the presuppositions that there exist images of the built environment and that memory and history can be embedded in them.

Brożek (2011) further defines the cognitive context of the question as “some convictions of a questioner which do not belong to the cognitive content of a question” but as “the convictions possessed by a questioner at the moment of asking” (p. 197), such as, in everyday situations, convictions about the resolvability of the question or the epistemic authority of the respondent. In the scholarly realm, the epistemic context may be interpreted as the set of currently accepted theories and the set of methodological directives of a given discipline (Brożek, 2011). Question (4) possesses assumptions related to the methodology for approaching the literary texts and the literary theories that inform the argument constructed from the textual analysis.

The concept of questions having assumptions related to cognitive content and cognitive context are of interest in their possible application at the domain level of discourse. What are the assumptions of domains’ questions relative to the questions’ content and context? Assumptions related to the content of domains’ questions are ontological in nature, constituting the phenomenon of interest in terms of the domains’ beliefs about the nature of reality, its entities, features, and relations. Question (4) can be examined for what it indicates about the nature of memory as an object of literary interest. By the question structure, we can deduce that memory has some relation to history, and that it can be embedded in images. Some ontological assumptions, or domain convictions about the question content, can be identified by the question structure alone.

Other convictions, those related to the epistemic context, are more tacit in nature and only emerge in comparison with other questions. Hookway (2008) defines the context of an utterance as “an evolving body of presuppositions, of things that are taken for granted by the participants, and, perhaps, are known to function as a body of shared background knowledge” (Hookway, 2008, p. 13). In both scientific inquiry and everyday inquiry, knowing which questions are relevant, how to reply, and what constitutes a “relevant” or “good” answer, is largely a matter of tacit knowledge. Jardine (1991) argues that scientific inquiry relies on “tacit criteria by which [scientists] assign burdens of proof and judge the competence and worth of other practitioners and their findings, tacit conventions of how to present materials to other practitioners, and the role of ‘habitual competence in the use of instruments’ in guiding experimental work (p. 90). This is the domain context, composed of propositions that are taken as certain, or at least uncontroversial, to those operating inside its boundaries. These tacit assumptions are best made visible by comparing domains’ question formulations, as illustrated by Fallis’s (2006) above example of shooting at birds on a fence. The differing set of assumptions related to the inquiry and the production of knowledge between the domains of mathematics and zoology become highlighted when their question variants relative to a common scenario are juxtaposed. Only in comparison to other questions, particularly those in other domains, will the epistemic context, or the domain’s epistemological assumptions, emerge.

### **3.4 Identifying and classifying questions in scholarly domains**

Questions, according to erotetic theory (Brożek, 2011), are those expressions that communicate the experience of a gapped cognitive picture of reality and the will to fill it,

structured in a manner that reflects the experience motivating the question (whether one has a hypothesis of an answer or not) and indicates expectations about the form and content of an answer. But the question, despite – or, given the tacit nature of much domain knowledge, because of – its central communicative and logical role in inquiry, often remains implicit in the knowledge products of inquiry. Erotetic theory offers a theoretical conception of the question according to its communicative function and logical structure that provides guidelines for recognizing the question when directly stated, or deriving it when it is implicit.

The characterization of the question as an expression with certain communicative functions and logical structures is employed in conjunction with Hookway's (2008) premise that knowledge sentences have indirect question correlates in order to identify the implicit questions of scholarly research from the knowledge products of inquiry. The definition of knowledge as a relation between the agent and the question (or, from a social epistemological perspective, between a knowledge domain and a question) allows Hookway (2008) to assert that knowledge sentences often have indirect question correlates. Hookway provides the example of the knowledge sentence, "John knows that 71 is a prime number," which has an indirect question correlate, whether 71 is a prime number. The indirect question correlate to "John knows how the internal combustion engine works" is, "how does the internal combustion engine work?" This proposition, that knowledge sentences have question correlates, is the key to identifying the implicit questions that organize scholarly inquiry. Questions, when not explicitly stated, can be identified as complements to the knowledge claims by reinserting volition into the declarative statement by the method of inversion and insertion of a question particle

(who, what, when, where, how, why, which, whether). Take the following literary topic statement:

This dissertation concerns the fate of a particular object of French collective memory, **François Fénelon**, investigating **how references to his name** in nineteenth-century literature through to the writings of Proust **reflect and affect the changing French imagination of him** whose posterity became a standard for the remembrance of grands hommes and pantheonization in the nineteenth century. (L9)

The topic is a declarative statement of the gapped cognitive picture of the question. In simplified form, and with an emphasis on the memory-related phenomenon in question, cultural memory, the declarative statement of the topic is reduced to the following form:

(10) This dissertation concerns how references to Fénelon's name in literature reflect and affect the cultural memory of Fénelon.

To deduce from the declarative sentence the question that produced the knowledge claim, volition must be reinserted into the statement through inversion and insertion of a question particle. Following this process, the question correlate is:

(11) How do references to Fénelon's name reflect and affect the cultural memory of him?

The derivation of the (11) question correlate from the (10) knowledge claim is achieved by reinserting the volitional aspect, the invitation of a response to fill in the gap in the picture of the situation, according to the logical structure of a completive question. The declarative statement (1) suggests that the question correlate should be structured as a completive question, which is confirmed by reference to (4), the answer. Completive questions are answered by filling in the gapped cognitive picture (of how references to Fénelon's name reflect and affect the cultural memory of him), while a hypothetive

question would be answered by confirmation or disconfirmation of the hypothesis of how to fill the gapped picture.

In addition to justifying and offering principles for the identification of explicit and implicit questions from the knowledge products of inquiry, the application of erotetic theory to domain-level questions suggests some dimensions or facets by which domains' questions can be classified. Questions have a communicative function, to express the questioner's experience of a gapped cognitive picture of reality and the will to fill it. The cognitive gap is expressed by the asking of the question. Chapter 2 organizes the question research into three basic paradigmatic approaches, differing according to the conception of the question-related phenomenon of interest and the context of the question. One of the central differences between the paradigmatic differences is the treatment of the question content. The question-as-object paradigm takes the content of the question at face value, accepting that the question has the ability to express a precise request for information from the information system. From the paradigmatic approach of questioner-as-subject, the content of the question must be negotiated from the question that expresses the compromised need back to the visceral need (Taylor, 1968), relative to the context of the individual's cognitive and situation states. This is the conceptual level at which erotetic theory constructs the question: the question as an expression of the gapped cognitive state of the questioner.

Applying the logical principles of erotetic theory to domain-level questions, the knowledge-domain-as-questioner experiences an *epistemic indeterminacy*, rather than a cognitive one. Whereas an individual's question communicates the experience of the individual's will to resolve an idiosyncratic indeterminate cognitive picture of a situation,

the knowledge domain's question communicates the experience of the domain seeking to resolve an indeterminacy in the current state of collective knowledge about the phenomenon. The epistemic indeterminacy, or what Dewey (1938) calls the "indeterminate situation" is a manifestation of the known unknown that is being pursued by the questioner, on behalf of the knowledge domain, through the formulation of a question and its subsequent answering. Asking a question is what allows reality to respond. The question is posed at reality, in the form of scientific nature or the products of human activity, as brought into focus by the question and answered, on behalf of that reality, by the knowledge domain. The scholar or researcher formulates questions, on behalf of the knowledge domain, and answers, on behalf of reality. The epistemic indeterminacy that the researcher, on behalf of the knowledge domain, seeks to fill is expressed by the *content* of the question. A logical philosophical approach to domain questions as having a communicative function of expressing the will to transform an indeterminate situation into a determinate one thus suggests that domain questions be classified by their content in relation to other domain questions in order to produce a picture of the domain state of knowledge.

Beyond categorizing domains' questions according to content, the erotetic characterization of questions as having a logical structure also suggests categorization of questions according to their *form*. As discussed in relation to the paradigmatic approaches to question research in Chapter 2, question answering research, described by the paradigmatic conception of question-as-object, is primarily concerned with the syntactic form of questions, given the context of automated information systems and their need to be able to parse sentences and make them comprehensible to the system for

retrieval of relevant documents. The information behavioral research that stems from the cognitive paradigm of the questioner-as-subject focuses on semantic form, on understanding what the question means, in the context of each questioner's individualized problematic situation. Erotetic theory deals with form on this level, linking the logical structure of questions to the meaning that the questioner is intending to communicate to the potential respondent. A questioning-as-intersubjective paradigmatic approach, in which the questioner speaks on behalf of the knowledge domain, shifts the focus to the question at the level of domain discourse. At the domain discursive level, question form carries meaning about shared standards and practices of knowledge production, which structure the production and formulation of an answer. Erotetic theory thus suggests that questions be classified according to their form, which is epistemic in nature.

Brožek's (2011) characterization of questions as distinguished from other expressions by their communicative function and logical structure dissolves the traditional distinction between the semantics and pragmatics of questions. The traditional semantic approach to questions examines the relations between questions-as-signs and their possible interpretations, while the pragmatic approach examines the relations between questions-as-signs and questioners or questioning contexts. Brožek distinguishes questions from declaratives and orders according to their communicative function, to communicate experiences consisting of gapped cognitive pictures of the world and the will to fill the gaps. The questioner formulates the question according to the logical structure that will most likely correspond to reality and thus be interpreted by the respondent in the manner that is desired to solicit the needed information to fill the gapped picture. This is both semantic and pragmatic: semantic in its consideration of the

meaning of the question, its possible interpretations, and pragmatic in its consideration of the use of the question, the relation between the questioner and question context. The application of erotetic theory to the current study of questioning as a social epistemological phenomenon, applying Brožek's (2011) conception of the question to domain questions, similarly views the semantic and pragmatic dimensions of question formulations as inextricably intertwined.

In summary, questions are characterized by their communicative function and logical structure (Brožek, 2011). The communicative function is to express the belief in the existence of an adequate picture of the situation (cognitive factor), a gapped picture (incognitive factor), and the will to fill the gap (volitional factor), transforming an indeterminate situation into a determinate one. The logical structure expresses the experience motivating the asking – the need to fill a gap (completive question) or confirm a conjecture of how to fill a gap (hypothetive question). When the question is not explicitly stated, this theoretical conception of the question, along with the proposition that all knowledge sentences have a question correlate (Hookway, 2008), allow the implicit question to be inferred from the declarative expressions of knowledge claims. The domain's gapped epistemic picture, the indeterminate situation, is communicated by the question content, while the epistemic structure within which an answer is produced is conveyed by the question's form. This theoretical framework will anchor the identification and categorization of domains' questions towards the pursuit of characterizing knowledge domains by their questions formulations, which convey information about what constitutes a relevant answer and the domain assumptions by

which the answer is produced. Chapter Five describes the development and application of this process to the three-domain sample.

### **3.5 Research questions, specific**

This dissertation seeks to situate the tension between the implicit and explicit dimensions of the question within the social epistemological context of knowledge domains. Questions serve a communicative function, to express a cognitive indeterminacy and the will to resolve it, and are logically formulated in accordance with domain norms of knowledge production. If knowledge domains are defined as thought or discourse communities that are part of society's division of labor – the labor of knowledge-based work – the implication is that domains should ask different questions and ask them differently. This dissertation seeks empirical verification of this proposition, and considers what the differences in question types indicate about the answers that follow and the domain assumptions that precede the questions.

A multidisciplinary topic of interest will be used to identify a sampling frame for studying the questions of contrasting domains. The topic of investigation is “memory,” which is deemed a topic that is currently of interest to academics in many fields as well as to the general public in relation to societal issues such as traumatic brain injury, neurodegenerative diseases, and healthy aging, and as central to the formation and maintenance of identity and culture. More specifically, the following research questions will guide the three-stage investigation.

*Stage One: Identification*

1. What questions do the knowledge domains of neuroscience, literature, and computer engineering formulate about the topic of “memory”?

*Stage Two: Categorization and comparison*

- 2a. What are the contents of neuroscience, literature, and computer engineering dissertations’ question formulations on the topic of “memory”?
- 2b. How do the contents of neuroscience, literature, and computer engineering dissertations’ question formulations on the topic of “memory” compare?
- 3a. What are the forms of neuroscience, literature, and computer engineering dissertations’ question formulations on the topic of “memory”?
- 3b. How do the forms of neuroscience, literature, and computer engineering dissertations’ question formulations on the topic of “memory” compare?

*Stage 3: Interpretation*

- 4a. What information do the comparisons between question contents convey about the answers that follow the neuroscience, literature, and computer engineering dissertations’ question formulations on the topic of “memory”?
- 4b. What information do the comparisons between question contents convey about the assumptions that precede the neuroscience, literature, and computer engineering dissertations’ question formulations on the topic of “memory”?

- 5a. What information do the comparisons between question forms convey about the answers that follow the neuroscience, literature, and computer engineering dissertations' question formulations on the topic of "memory"?
- 5b. What information do the comparisons between neuroscience, literature, and computer engineering question forms convey about the assumptions that precede the neuroscience, literature, and computer engineering dissertations' question formulations on the topic of "memory"?

Kearsley's (1976) observation, that questions indicate information as well as request it, is here put to service as a means to characterize knowledge domains by the questions that they formulate about a common topic. Stage One consists of the identification of the three knowledge domains' question formulations, based on Hookway's (2008) observation that all knowledge has a question correlate. Research question one directs inquiry towards the development of a method for identifying implicit questions from the knowledge products of inquiry.

In Stage Two, domains' question formulations are categorized and compared. Research questions 2a and 3a characterize the question formulations according to content and form, or what they ask about and how they ask. The content of a question is declarative of the indeterminate situations, the known unknowns that the questioner is seeking to fill on behalf of the domain, while the form indicates the logical structure of the inquiry. These questions will produce knowledge of how domains can be characterized according to their question formulations, creating a functional question profile of each domain on the topic of "memory." Questions 2b and 3b invite comparison

of the content and form of domains' question formulations in order to identify the varying approaches to "memory" found within and between the three domains.

In Stage Three, the comparisons of domains' question formulations are further analyzed and interpreted to shed light on the organizing functions of the question itself, namely, its ability to indicate information about the answers that follow the question and the domain assumptions that precede it. Comparison across contrasting domains makes visible the unstated assumptions of each domain, thus highlighting the formal dimensions of the phenomenon (Zerubavel, 2007), in this case, of questioning. Research questions 4a and 5a focus on what question content and form dictates about the content and form of the answers that follow, while questions 4b and 5b consider what they indicate about the assumptions that precede the questions. In this manner, the current investigation seeks a path out of the question paradox by recasting questions as social epistemological objects and tools of domain inquiry.

### **3.6 Conclusion**

This dissertation investigates the relations between knowledge domains, their questions, answers, and assumptions related to inquiry and the production of knowledge. A narrow focus on the question, in this case as presented in the knowledge products of scholarly research, is compelled by theoretical, methodological, and pragmatic reasons. Theoretically, the analysis of different domains' question formulations about a shared topic of interest aims to find a way out of the question paradox – that in order to ask, the questioner must know enough to know what is unknown (Flammer, 1981) – by testing the supposition that domains' question formulations indicate information (Kearsley, 1976) about the domain norms of knowledge production. Methodologically, a focus on

questions allows for a comparative study of domains, which Wilson (1994) suggests is one of the reasons that LIS has produced few significant theories with explanatory power.

Finally, a close understanding of how to identify questions in knowledge products and knowledge of what questions convey about knowledge domains is of pragmatic value to domain analysis, suggesting that one of the ways in which domains can be described is by their questions. A focus on questions has implications for knowledge organization, in areas such as the representation and classification of documents, and production of secondary documents such as indexes, subject research guides, and bibliographies. The research questions focus the investigation on the content and form of domain questions about a common topic in order to discern differences in what and how domains ask, what and how they answer, and the assumptions upon which these determinations rest. Chapter Four presents the comparative methodological approach by which the research questions will be explored.

## **CHAPTER 4: RESEARCH METHODOLOGY AND DESIGN**

### **4.1 Overview**

Chapter 3 describes a theoretical framework for the identification and comparative analysis of research questions about the topic of “memory” as posed by three contrasting scholarly knowledge domains. Domain analysis provides a characterization of knowledge domains as the social units of knowledge production, defined along ontological, epistemological, and social dimensions, which is encapsulated in the question formulations that drive inquiry. This chapter outlines a domain analytic methodological approach to studying questions and answers. As a meta-theoretical framework for library and information science (Hjørland, 2010), domain analysis is a comprehensive methodological context for the interpretation of bibliometric and empirical user studies (Hjørland and Albrechtsen, 1995). This chapter develops a comparative methodology from the meta-theoretical assumptions of domain analysis, following the example of Brenda Dervin’s (1992) development of the Sense-Making Methodology as meta-theory, theory, and methodology. The comparative domain analytic methodology informs the three-stage research design for studying domains according to their question formulations.

### **4.2 A comparative domain analytic methodology**

The potential for domain analysis to serve as meta-theory, theory, and methodology is modeled after the example offered by Dervin’s (1992) Sense-Making Methodology. Dervin (1992) describes Sense-Making as a set of meta-theoretic assumptions and theoretical propositions about the nature of information, the nature of

human use of information, and the nature of human communication, that also implies methodology and methods:

The assumptions and propositions of sense-making, taken together, provide methodological guidance for framing research questions, for collecting data, and for charting analyses. Derived from these assumptions are [sic] a set of methods, particularly methods for interviewing humans about their experiences.” (p. 62)

Whereas Sense-Making is concerned with a constructivist understanding of how people experience and make sense of phenomena, domain analysis posits a collectivist or social constructionist approach to studying the nature of knowledge production, with knowledge domains as the objects of study, as described in Chapter 3: Theoretical Framework. From the meta-theoretical assumptions and the theoretical propositions of domain analysis, methodological principles are extracted that suggest the framing of research questions, modes of data collection and analysis for the current study of domains’ question formulations.

**4.2.1 Domain analysis as meta-theory and theory.** The central meta-theoretical assumption of domain analysis is that the primary object of study in information science is knowledge domains and knowledge structures rather than individuals and individuals’ cognitive structures (Hjørland & Albrechtsen, 1995; Hjørland, 2010). At the highest level of abstraction, knowledge domains are described as thought communities defined by ontological, epistemological, and social dimensions that interact in complex ways to constitute a thought or discourse community (Hjørland & Hartel, 2003a; Hjørland, 2010). Domain analysis shifts the focus from individual cognition and information needs,

seeking, and use behaviors to knowledge structures and knowledge domains' information activities and practices. Hjørland (2010) bases domain analysis on a view of "pragmatic realism," which claims that a mind-independent reality exists, though it is not given that any given individual, collective, or humankind as a whole, grasps or has true knowledge of that reality, or that science accurately reflects that reality. Objective knowledge exists as separate from subjective knowledge, but this objective knowledge is not of the natural sort that is conceived of by fundamentalist paradigms such as empiricism or rationalism. Rather, objective knowledge is most likely to be approached by contextualizing individuals' subjective knowledge to the collective knowledge that exists within domains (Hjørland, 2010).

From these meta-theoretical assumptions, sets of propositions can be identified for explaining knowledge-related phenomena and the relations between them, suggesting that domain analysis can function as a theory as well as meta-theory. Domain analysis has been employed to explain characteristics of single domains as well as to draw comparisons between contrasting domains. In an example of a single domain study, Ørom (2003) employs domain analysis to explain the knowledge organization of the domain of visual art relative to three paradigms in art scholarship (the iconographic, the stylistic, and the materialist) and their relation to existing taxonomies of the domain. Other single domain analytic studies include an epistemological reading of the indexing of musical genres (Abrahamsen, 2004), a symbolic interactionist study of the nursing knowledge domain (Sundin, 2004), and a taxonomic domain analysis of social work (Zins and Guttman, 2004). At the comparative level, domain analysis has been employed to develop theoretical propositions about the use of e-journals and databases in four

domains that are distinguished by domain size, degree of scatter in the domain, and domain-specific relevance criteria (Talja and Maula, 2003); information practices across four scholarly fields (Fry, 2004); the use of digital library resources according to research culture (Talja and Vakkari, Fry, and Wouters, 2007); and conceptual modes of digital access in the sciences and humanities (Palmer, 2005). In each of the studies, domain analysis is employed as a theory that proposes that information practices emerge from the ontological, epistemological, and social dimensions of knowledge domains.

**4.2.2 Domain analysis as methodology.** Dervin (2003) defines methodology as a bridge between meta-theory and theory: methodology rests “on a fundamental set of philosophic assumptions about the nature of human Sense-Making (and sense unmaking) which, in turn, mandates a specific set of methodological moves” (p. 27). Methodology also “opens up or closes down theoretical possibilities” and “mandates attention to certain ‘primitive terms’” (Dervin, 2003, p. 27); it rests upon meta-theoretical assumptions while constraining theoretical propositions. Domain analysis as a methodology relies upon philosophic assumptions about the nature of knowledge production (domain analysis as meta-theory) and simultaneously suggests theoretical possibilities vis-à-vis attention to certain “primitives” (domain analysis as theory). The “primitives” briefly discussed here are based on Hjørland and Albrechtsen’s (1995) list of central concepts for domain analysis. In some cases, the “primitive” concepts are contrasted with the corresponding concepts in the cognitive viewpoint, in relation to which domain analysis positions itself.

- Knowledge – In contrast to the abstract notion of information, knowledge is a social phenomenon, situated in a particular space-time context and held by particular subjects.

- Documents – Documents are inherently context-rich, a product of the social nature of their creation, circulation, and use in the production of new knowledge.
- Subjects – The “knowing subject,” as contrasted with the abstract “user” of information, perceives reality through the lens of the knowledge domain (Hjørland & Albrechtsen, 1995). Rather than erase individual agency for the sake of the structure of knowledge domains, the individual is understood in socio-cognitive terms as seeking to align or otherwise define one’s self to the domain context or contexts in reference to which knowledge is being produced.
- Knowledge structures – The “knowing subject” operates within and between existing structures of knowledge that frame their view of reality, what constitutes knowledge, and how it is known, represented, and circulated.
- Information practices – Domains are constituted by information practices. As a subset of the more fundamental concept of the social practices that constitute the social world (Schatzki, 2001), information practices are embodied, materially mediated arrangements of information activities centrally organized around a shared practical understanding.

These primitives speak to the status of domain analysis as offering an alternative to methodological individualism, in the form of methodological collectivism (Hjørland and Albrechtsen, 1995). The methodological collectivist viewpoint sees inquiry as a social or cultural process and knowledge as its product, while also acknowledging that collectives

are comprised of individuals with agency in relation to the social structures of the domain.

The methodology of domain analysis offers guidance for the formulation of research questions, data collection, and data analysis through the orienting framework of these “primitive” concepts. The methodological principles and primitives of domain analysis suggest that since knowledge is a social phenomenon, the questions that drive and organize inquiry must also be social in nature. Moreover, the social unit of significance is the knowledge domain, which is participated in by “knowing subjects” and constituted by information practices, of which question asking and answering is but one type. In this social epistemological context, documents fulfill their function of scholarly communication if the knowledge represented within meets the ontological commitments and epistemological presuppositions of the knowledge domain. Documents, as domain knowledge products, can thus be considered a site of study for the domain-based nature of inquiry.

Like Sense-Making Methodology, which is a “methodology between the cracks” (Dervin, 2003), domain analysis exists between the dichotomies of quantitative versus qualitative methods; theoretic versus applied research; individualistic versus structural research; and administrative versus critical research. This is due to the conceptual flexibility of the central ontological object of interest, the knowledge domain. The concept of a knowledge domain is most easily applicable to those domains in which knowledge production is the primary purpose, hence the focus of the existing research on scholarly domains. But the concept is extendable to all domains that produce and justify knowledge claims, even if that is not the express purpose of the domain as it is with

scholarly domains. Fleck's (1986) notion of the "thought collective," which enables and constrains one's perception of reality and the language available for representing it, is apt in this regard, as one can easily call to mind examples of thought collectives outside of academia: religious sects, political parties, artistic subcultures, professions, hobbyists. Hartel's (2007) study of gourmet cooking as a hobby domain is a notable exception to the scholarly focus of domain analysis and is particularly important for its depiction of how a domain is constituted by shared information practices.

**4.2.3 A comparative approach.** Comparison is the oft-unacknowledged backbone of qualitative research (Silverman, 2013). Whether the comparison is between cases, social groups, contexts, geographical or political configurations, or any of these at different points in time, comparison highlights differences amongst similarity, which reveals the sociological dimension. Hjørland (2010) calls for domains to be studied singly and comparatively, stating that "The examination of how knowledge domains differ on some points and are similar on other points is important to construct 'a general information science' that is not just an empty abstraction'" (p. 1652). Compared to other types of social research, LIS rarely uses comparative methodologies, tending instead to study single subject domains or broad domain groupings, producing many domain-specific findings but little insight into the nature of domain-general or phenomenally focused information activities and practices. The near-exclusive focus on single domains is rooted in the subject expert view of librarianship, which prioritizes deep knowledge of a subject area rather than cross-subject comparative knowledge.

Mills (2008) points to Max Weber's comparative sociology for revealing the power of comparison to foreground uniqueness, pointing out that "Comparisons not only

uncover differences between social entities but also reveal unique aspects of a particular entity that would be virtually impossible to detect otherwise” (p. 3). This is what Knorr Cetina (1999) calls “comparative optics” as a framework for seeing: looking at one domain through the lens of the other in order to “visibilize” the invisible, with “each pattern detailed in one science serves as a sensor for identifying and mapping (equivalent, analog, conflicting) patterns in the other” (p. 4). In contrast, a focus on similarity across domains signals a search for universals or underlying general processes across contexts or categories (Mill, 2008). This kind of comparison brings out essential features and forms of the phenomenon of interest, as recognizable by their specific instantiations. Zerubavel (2007) situates this type of comparative social research methodology within historical sociological precedents as context for articulating a method called social pattern analysis, which is purposefully oblivious to idiosyncratic differences, instead looking for general patterns that transcend the specific instantiations. The current study engages in both types of comparisons, seeking to “visibilize” the comparative differences between domains’ question formulations, while also searching for similarities in the relation between question dimensions and domain assumptions.

The first comparison undertaken is of domains according to their question formulations. Dillon’s (1990) empirical study of the practice of questioning demonstrates that domains such as the classroom, courtroom, journalistic interview, and survey research utilize questions differently, have different expectations for answers, and reflect different social dynamics between questioner and respondent. The current study explores this insight in the context of the LIS conception of knowledge domains, asking: do different knowledge domains formulate questions differently relative to a common topic?

The underlying proposition guiding this comparison is that knowledge domains can be distinguished by their question formulations, which subsequently produce different answers. Implicit in this question is the need for a method of identifying and comparing questions, to which we turn to the logical structure and communicative function of questions, as described in Chapter 3: Theoretical Framework. Armed with a method for identifying domains' question formulations, the formulations can be compared in order to determine the salient characteristics by which they differ from each other.

In order to make visible the domains' assumptions, a second type of comparison is needed: a comparison of question categories for their inherent assumptions. Each domain's question categories, comprised of content and form, will be compared in order to make visible the tacit assumptions of inquiry. The movement from comparing domains to comparing question categories within and across domains allows for the likely possibility that domains may be characterized by more than one question type, each representing a different set of assumptions about the nature of knowledge production on the topic. Focusing on question categories rather than pre-defined domain boundaries places the question at the center of this inquiry, rather than the knowledge domain. In other words, this use of the comparative approach is not aimed at a members' understanding of domains as much as it is of the question itself as an epistemological tool of inquiry.

Hub Zwart's (2008) *Understanding Nature: Case Studies in Comparative Epistemology* serves as an additional guide for the second type of comparison, of questions according to their ontological and epistemological assumptions. Through a series of case studies, Zwart compares the ways of knowing in relation to the subject of

“nature,” as evidenced in various works of literature including Herman Melville’s *Moby Dick*, Ibsen’s play, *The Wild Duck*, Jack London’s *The Call of the Wild*, and Jules Verne’s *Around the World in Eighty Days*. Characters in these works exhibit different “epistemological profiles” or “styles” in relation to “knowing” plants, animals, and the natural environment, ranging from scientific to experiential and intuitive. The book, says Zwart (2008), “starts from the conviction...that there are *other* ways of knowing about nature besides science” (p. 4), more intimate ways that are better captured by literary works than academic discourse. Art and science both serve as perspectives that allow nature to emerge *under certain conditions*, and as such, neither is a straightforward representation (p. 5). The methodological power of comparative epistemology is that it forces critical reflection on the structure and reliability of knowledge forms, making visible the assumptions that drive knowledge claims and their apparent truthfulness.

In addition to Zwart’s (2008) “ways of knowing,” or epistemological profiles, the current study is also interested in comparing “ways of seeing,” or ontological profiles. Zwart’s case study method favors the use of concrete examples rather than an abstract treatment of epistemological issues, which he marks as an “empirical turn” in epistemology (p. 8). His central question is: What is the epistemological profile of science in general, and of the life sciences in particular, in comparison to other forms of knowledge concerning living nature? Following his example, our central question for the second stage of comparison is: What is the ontological and epistemological profile of the different question categories in comparison to one another concerning “memory”? The comparative analysis of question categories for their implicit assumptions will focus on ontological and epistemological assumptions.

### 4.3 Research design

The comparative domain analytic methodology is implemented towards the study of domain questions and what they convey about answers and assumptions by the three stage research design outlined in Table 8. The first stage employs a logical philosophical conception of questions to develop a method for formulating domains' questions from the knowledge products of scholarly inquiry. The second stage categorizes and compares the questions according to content and form, resulting in a question profile of each domain relative to the topic of "memory." The third stage employs comparison to make visible the assumptions that are implicit in the question types, resulting in an ontological and epistemological profile of the research on "memory" as represented by the sample.

Research question	Data sources	Data analysis	Results
<i>Stage One: Identification</i>			
1. What questions do the knowledge domains of neuroscience, literature, and computer engineering formulate about the topic of "memory"?	Abstracts	- Coding for question-related segments - Logical formulation of questions	Question formulations about "memory"
<i>Stage Two: Categorization and comparison</i>			
2a. What are the contents of domains' question formulations on the topic of "memory"?	- Results from Stage 1 - Interviews with authors	- Inductive coding of subjects - Deductive coding of queries	Question content categories (query-subject pairings)
2b. How do they compare?			
3a. What are the forms of domains' question formulations on the topic of "memory"?	- Results from Stage 1 - Interviews with authors	- Inductive coding of forms	- Question forms
3b. How do they compare?			
<i>Stage Three: Interpretation</i>			
4a. What information do question contents convey about the content of answers that follow the questions?	- Results from stages 1 and 2 - Interviews with authors - Full-text dissertations	- Inductive coding of answer contents - Interpretive and theoretical coding of assumptions	- Answer contents - Assumptions of question contents
4b. What information do question contents convey about the assumptions that precede the questions?			

5a. What information do question forms convey about the answers that follow the questions?	- Results from stages 1 and 2 - Interviews with authors - Full-text dissertations	- Inductive coding of answer forms - Interpretive and theoretical coding of assumptions	- Answer forms - Assumptions of answer forms
5b. What information do the question forms convey about the assumptions that precede the questions?			

**Table 8. Overview of research design**

One of the central methodological problems of comparative research is the selection of cases for comparison, including the unit, level, and scale of analysis (Mills, 2008). This has proven true for domain analysis, where the problem of how to define a domain remains a fundamental issue for theory and praxis, which debate is summarized in Chapter 3: Theoretical Framework. Ragin (2013) distinguishes between “given” and “constructed” populations: “given” populations being historically and structurally formed, such as nation-states, while “constructed” populations are theory-driven and constructed by the researcher. The current study engages the debate about domain definition by testing the proposition that the given populations, knowledge domains as self-identified by the classification of dissertations about “memory,” coincide with the theoretical populations of knowledge domains as constructed by their question types.

While the conceptual definition of knowledge domains by domain analysis encompasses scholarly, professional, and everyday social domains, existing research focuses mainly on the scholarly realm. Scholarly domains differ from professional and everyday realms because their defining purpose is the production of knowledge, communicated through the production and circulation of knowledge products such as dissertations, journal articles, conference papers and presentations. The infrastructure of scholarly domains is constructed around the circulation of knowledge products, and the knowledge products themselves are highly structured for findability and clarity of

communication. Scholarly domains, rather than professional or everyday domains, are chosen for this study because they produce knowledge products that are highly structured according to the epistemic concern of justification, making them more amenable to the study of the questions that drive and organize inquiry according to domain assumptions.

**4.3.1 Selection of topic and domains.** The study introduces a novel, topic-driven method for selecting domains for comparison. As inter- and multi-disciplinary research approaches to topics of societal currency increase in frequency and importance, the need for understanding different domains' approaches to knowledge production also increases. Thus, at the pragmatic level, this topic-driven method for domain sampling reflects the reality of growing interest in multi-disciplinary efforts of knowledge production. At the theoretical level, a topic-driven study of domains allows for domain differences to emerge as not general to the domain production of knowledge, but as specific to the domain production of knowledge about the topic of interest. Simultaneously, as Zerubavel's (2007) social pattern analysis demonstrates, the formal dimensions of questioning become visible by identifying the common characteristics of the phenomenon across diverse contexts.

An initial search of dissertation research in the ProQuest Dissertations and Theses Database was conducted in order to find a topic that fit the following criteria for selection:

- *Scale of analysis* – The scale of analysis should lie between what Ragin (1987) terms a small-N case-driven scale (high validity) and large-N variable-driven scale (high reliability). The aim is to get a sense of larger domain

patterns while preserving depth of analysis. Practically speaking, the number of dissertations produced over a five-year period (2006-2011) was deemed a reasonable size for the analysis of meta-data fields related to domain membership and for more intensive coding of abstracts for the analysis of abstracts in Stages 1 and 2.

- *Major domain focus* – The topic should be of significant interest to a few domains rather than a minor interest of many domains. This ensures that there can be said to be a domain approach to inquiry regarding the topic, rather than the coincident interest of a few researchers.
- *Contrasting domains* – The domains producing the most dissertations should contrast according to historical tradition (i.e., natural sciences, social sciences, humanities) or along epistemic and structural dimensions of the discipline, such as Becher's (1979) axes of hard-soft, pure-applied, and life-nonlife.

Among the topics considered were: climate change, evolution, unemployment, immigration, and memory. ProQuest Dissertations and Theses Database was searched for any dissertations completed between 2006 and 2011 in which the topical search terms were in the title, abstract, or keyword field. Of these topics, climate change and evolution were heavily dominated by the natural sciences, unemployment and immigration heavily dominated by the social sciences, and all four produced too much research to be manageably analyzed, numbering between 500 and over a thousand dissertations in a five-year period. The topic of “memory” produced a relatively manageable 420 dissertations for metadata analysis and engaged a diverse set of domains.

Having identified a topic for domain comparison, four metadata fields were considered for their ability to stand in for domain identification: “classification,” “subject,” “keyword,” and “department.” “Subject” was found to mirror the terms in “classification,” making them functionally identical, with the only difference being that “classification” included a number identifier, indicating the use of the field for indexing by ProQuest. The “keyword” field is defined by a lack of controlled vocabulary and user indexing and as a result, produces up to 16 terms per dissertation that reflect topics, sub-topics, discipline, specialty field, methodology, theory, practice and other miscellaneous terms, proving too idiosyncratic for identifying domains. “Department” is an indicator of the institutional affiliations that may have some relation with domain boundaries, but this field is not populated by all dissertations. Thus, the “classification” field was determined the best metadata field for identifying domains as historically and politically “given” populations.

Table 9 lists the classification and count of the dissertations resulting from a search of the ProQuest Dissertations and Theses Database on the topic of “memory” from 2006 to 2011. Classification fields sharing a base term but different modifiers were combined; for instance, “Cellular Biology” and “Molecular Biology” are subsumed into the category of “Biology.”

<i>Classification</i>	<i>No.</i>
Neurosciences	87
Psychology [Gen (9), Cognitive (27), Clinical (14), Developmental (11), Educational (10), Social (7), Experimental (4), Occupational (1)]	83
Engineering [Computer (28), Electrical (19), Mechanical (5), Biomedical (2), Automotive (1)]	55
Literature [Comparative (10), Modern (9), American (4), Romance (3), African (2), Asian (2), Caribbean (1), Germanic (1)]	32
Computer science	19
History [Gen (1), European (7), American (3), Art (3), Religious (3), Black (1), African (1)]	19
Biology [Cellular (10), Molecular (8)]	18

Cultural anthropology	8
Ethnic Studies (Asian (4), African American (3), Black (1))	8
Chemistry [Gen (1), Polymer (4), Organic (1), Physical (1)]	7
Physics [Gen (2), High Temperature (1), Quantum (1), Solid State (1), Condensed Matter (2)]	7
American studies	6
Mathematics [Gen (1), Applied (3)]	4
Psychobiology	4
Speech therapy	4
Genetics	3
Gerontology	3
Materials science	3
Mental health	3
Nursing	3
Philosophy [Gen (2), Philosophy of (1)]	3
Aging	2
Biblical studies	2
Immunology	2
Marketing	2
Mechanics	2
Music	2
Nanotechnology	2
Religion	2
Virology	2
Archaeology	1
Audiology	1
Biographies	1
Biostatistics	1
Business administration	1
Education	1
Ethics	1
European Studies	1
Evolution and Development	1
Geography	1
Geophysics	1
Instructional Design	1
International Relations	1
Kinesiology	1
Management	1
Language	1
Linguistics	1
Medical imaging	1
Medicine	1
Morphology	1
Political science	1
Surgery	1
Womens studies	1

**Table 9. Dissertations on “memory,” 2006-2011, by classification field**

Table 9 shows the diversity of research approaches to the topic of memory, with four domains producing substantially more dissertations than the rest: neuroscience,

psychology, engineering, and literature. Both neuroscience and psychology are hard-pure fields (with the exception of the subset of clinical psychology), so neuroscience was chosen as it produced more dissertations. In contrast, engineering is a hard-applied field; literature is a pure-soft field. These three domains were chosen for comparison as producing the most dissertations and differing according to the hard-soft and pure-applied axes<sup>8</sup>. Initial readings of the engineering dissertation abstracts indicated that each subset was quite distinct in the construction of the phenomenon of “memory,” so computer engineering was chosen as the subset with the most dissertations. On the other hand, though the literature dissertation identified according to many subsets, the construction of “memory” was indistinguishable among them upon initial review, so all of the literature subsets were subsumed into the literature sample. Dissertations that were not centrally about “memory” were eliminated, resulting in 57 dissertation entries in neuroscience, 20 in computer engineering, and 20 in literature, for a total of 97 abstracts.

**4.3.2 Data collection.** As one of the primitive concepts of domain analysis, knowledge domains’ documents are a primary data source for single and comparative studies of domains. Documents are informative of domain characteristics in at least two senses: first, for their function in the production of knowledge, such as is of interest in studies of document relevance. Second, documents are of interest as knowledge products or inscriptions of domain practices. It is this second sense in which this study utilizes documents as the primary source for comparing domains: as records of the domain practice of questioning. Documents are useful for the study of information practices

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<sup>8</sup> Most researchers employing Becher’s (1979) typology to classify scholarly knowledge domains exclude the life-nonlife continuum as forcing choices that do not necessarily reflect disciplinary boundaries, such as is the case in the field of educational technology (Czerniewicz, 2008).

because they provide behind-the-scenes look at practices that are not directly observable (Isah, 2008) such as the socio-cognitive aspects of questioning. In academic domains, documents play an especially central role in establishing and maintaining domain membership. Paré, Starke-Meyerring, and McAlpine (2009) go so far as to define academic communities as being textually constituted:

another distinguishing feature of the academic workplace, is that one's community of practice is first encountered textually, as a disembodied collective dispersed over time and space. In what other line of work might a long-dead colleague continue to influence the current conversation? Where else are one's fellow workers—those with whom one might interact (textually) every day—encountered face-to-face only once a year at an annual association meeting? The doctoral student seeking passage to disciplinary membership must locate herself in a textually constituted community. (Paré, Starke-Meyerring, & McAlpine, 2009, p. 184)

The vast majority of scholarly communication takes place via the circulation of documents, rather than face-to-face: documents are not simply fossilized records of the process of knowledge production, but are themselves dynamic entities that are fundamental to the ongoing constitution of domains' knowledge structures. Documents, mainly dissertation abstracts, along with a sample of full-text dissertations, are the primary data source for studying these textually constituted communities.

**4.3.2.1 Dissertations and abstracts.** While scholars produce many types of documents such as conference papers, journal articles, books, lecture notes and materials,

reports, grant applications, and more, dissertations were chosen for the study of domains' questions for several reasons. In order to make comparisons between and across domains, what is needed is a document type that is regularly produced in all domains. Of all the types of documents produced by scholars in the arts and sciences, dissertations are the one type of intellectual product that is required of almost all aspiring scholars, at least those traveling the conventional route to establishing credibility in the knowledge domain by obtaining a doctoral degree. Books may be favored in the humanities, but are rarely written in the physical sciences; journal articles are the mainstay of physical, applied, and social sciences, but of marginal importance in the arts and humanities. On the other hand, every doctoral candidate must produce a dissertation.

From the social epistemic perspective, dissertations are simultaneously the culminating product of the process of scholarly socialization and the initial intellectual product of one's scholarly career. In considering the dissertation as a genre, Paré, Starke-Meyerring, and McAlpine (2009) observe that, "On one hand, it is the ultimate student paper, the final school-based display of knowledge and ability. On the other hand, it is often – in whole or in part – the first significant contribution to a disciplinary conversation" (p. 179). The dissertation is evidence of successful socialization into a knowledge domain, a form of legitimate peripheral participation (Lave and Wenger, 1991) that takes place under the tutelage of a full member of the collective: the dissertation advisor (Paré, Starke-Meyerring, & McAlpine, 2009, p. 182). Dissertations serve as evidence that the scholar is a competent practitioner according to the domain's standards of participation in the work of knowledge production. The competent practice of domain membership in the production of a dissertation is displayed in choosing a

“relevant” topic, designing and conducting the inquiry according to domain norms, justifying findings according to the practices of the domain, use of language and rhetorical style, etc. The full text of select dissertations chosen to represent each question category are reviewed in order to glean further insight and gather additional evidence for characterizing the differences between domains according to their questions, answers, and assumptions. The focus of the full text dissertation analysis is particularly on identifying domain assumptions (ontological, epistemological, pragmatic, etc.) that are implicit in the question categories and made visible by their comparison.

As a data source, the dissertation abstracts should be representative of the dissertation as a domain-based knowledge product. Rather than viewing abstracts as a lacking-but-necessary summary of a knowledge product such as a dissertation or journal article, it is here considered as a knowledge product in its own right. Constructed for the explicit purpose of communicating the knowledge produced by the research and its significance to the domain in the most concise language possible, the abstract displays all of the elements of domain-based inquiry: the question being pursued, the answer that is produced in reply and its mode of production, and, in what is stated and unstated, the explicit and tacit assumptions that shape inquiry. Thus, the abstracts serve as an important data source for the identification and comparison of domain questions.

**4.3.2.2 *Semi-structured interviews.*** Interviews are another documentary source that will be used to guide the interpretation of results from the analysis of dissertations and abstracts. Interviews were conducted from October to February 2014 with fourteen authors representing all six of the question types. The interviews took place via Skype or phone and lasted between 40 and 120 minutes. Transcribe.wreally.com was used to

automatically transcribe the audio of the interviews, which were then checked manually for accuracy. Exempt status was granted from Rutgers University's Institutional Review Board Review (Protocol #: E13-325) on September 13, 2014.

The interview protocol consists of semi-structured questions designed to elicit practitioners' talk about how they chose dissertation topics, what influenced the choice, and how they define their domain's boundaries. The interview questions were designed around several themes as they relate to the research questions: identification of the dissertations' research questions, identification of domain or domains of participation, and the author's general understanding of what constitutes a relevant question in the domain. Spradley's (1979) strategies of ethnographic interviewing were employed. Descriptive questions were utilized to elicit initial talk, followed by structural questions to encourage elaboration of the phenomena of interest and contrast questions to reveal the dimensions of meaning related to the phenomena of questioning. The interview protocol is included as Appendix A.

**4.3.2.3 Subject literature.** Domain-specific subject literature serves a two-fold purpose: (1) as a general introduction to domain understandings of the topic of "memory" and (2) as a guide for interpreting results of the analysis of dissertations and abstracts. Several introductory texts were utilized in order to gain familiarity with the relevant terminology and conceptual approaches of the domains' research on the topic of "memory." Additionally, the subject literature was referred to if needed in order to confirm or disconfirm findings about the domain questions, answers, and assumptions.

## 4.4 Data analysis

Analysis of the data at each stage corresponds to the research questions as shown in Table 8. The first stage of analysis entails the formulation of questions from the dissertation abstracts. The second stage characterizes the questions according to content and form in order to create a question profile of each domain's research on "memory." The question content-form categories are compared within and across domains, producing a picture of the various approaches to knowing about "memory" within and between the three domains. Stage Three entails an interpretive analysis of the results from the Stages one and two, along with additional analyses of the interviews and full text dissertations, in order to make visible the assumptions about the nature of knowledge production inherent in the question formulations, creating an ontological and epistemological profile of each domain's research on "memory." All data was imported into NVivo for Mac (Version 10.2.0) for qualitative coding. Coding procedures, consideration of code labels and usage, code-related theoretical insights, and all other manner of research-related processing were recorded as research memos.

**4.4.1 Identifying domains' question formulations (Stage 1).** The first stage of analysis entailed the formulation of questions from the dissertation abstracts. Abstracts were subjected to repeated close readings in order to become immersed in the abstract format, language, and structure in the three domains. Stage One entailed a two-step process for identifying the dissertations' question formulations.

1. Segments of the 97 abstracts with any information pertinent to identification of the "question" were broadly coded as "question" (Figure 1). This was guided by the logical philosophical conception of questions, described in Chapter 3, as

expressions that communicate the gapped cognitive picture of the world (Brožek, 2011) or the indeterminate situation regarding “memory.” In Figure 1, the indeterminate situation concerns whether there is a difference in the verbal and visual working memory of children and adolescents, aged 6 to 18, in three groups: those diagnosed with Attention Deficit Hyperactive Disorder (ADHD); those with ADHD and anxiety; and those with ADHD and depression. Simultaneous identification of the answer-indicative segments aided in the identification of the **question**-indicative segments.

Children diagnosed with ADHD and children diagnosed with ADHD with comorbid anxiety or depression: Exploring the differences in working memory performance

This study was a descriptive quantitative causal-comparative research design. **Verbal and visual working memory performance was examined in children and adolescents diagnosed with ADHD and ADHD with comorbid anxiety or depression. Male and female participants, aged 6 to 18 were assigned to research groups based on diagnosis. Children and adolescents with a diagnosis of ADHD comprised one group, a diagnosis of ADHD with comorbid Generalized Anxiety Disorder or Anxiety Disorder, NOS comprised a second group, and ADHD with comorbid Major Depressive Disorder, Dysthymic Disorder or Depressive Disorder, NOS comprised a third group.** Archival neuropsychological test data was utilized and working memory performance was measured by the Wide Range Assessment of Memory and Learning-Second Edition (Sheslow & Adams, 1990). An Analysis of Variance (ANOVA) was conducted to compare statistical means of the three research groups. The ANOVA demonstrated statistically non-significant differences in verbal, visual, and overall working memory performance between the research groups. Further research is warranted to increase knowledge of working memory performance in children and adolescents diagnosed with ADHD with comorbid anxiety or depression.

**Figure 1. Example of “question” and “answer” identification in abstract**

2. The formulation of the dissertations’ questions are based on the “question” and “answer” segments, in accord with the communicative function and logical structure of questions described in Chapter 3: Theoretical Framework. Declarative statements such as “This dissertation studies...” or “The focus of this research...” or “I will show...” were transformed into interrogatives, either complete (using open-ended interrogative words such as: who, what, when, where, why, how) or hypothetive (using close-ended words such as which,

whether, does and is). This transformation was done in a constant comparative manner within each domain. The question segment in Figure 1, in the context of the other neuroscience abstracts, was transformed into the hypothetical question: “Is there a difference in working memory performance between children and adolescents with ADHD, ADHD with anxiety, and ADHD with depression?”

This two-step process results in the formulation of the dissertations’ questions, such that each dissertation is represented by a single question. The straightforward abstract in Figure 1 hardly requires theorizing in order to identify the question and answer, but it is in the minority among the sample of 97 abstracts. The need for a theoretical conception of questions as having a communicative function and logical structure is much more apparent in seeking to identify questions and answers in the non-hypothesis-driven abstracts, such as those in literature, computer engineering, and even in parts of the neuroscience domain.

Stage One produces a list of the question formulations driving inquiry in the dissertations about “memory” in a consistent form. This consistency allows for the comparison of questions within and across domains, which is the focus of Stage Two.

#### **4.4.2 Categorizing and comparing domains’ question formulations (Stage 2).**

Having identified the question formulations in the three domains’ dissertation abstracts, Stage Two seeks to categorize and compare the question formulations within and between the domains. The data source for this stage is results from the Stage One analysis, in the context of familiarity with the abstracts and a sampling of full text

dissertations in each domain. Author interviews and introductory subject literature are also utilized to guide the domain interpretations. What is sought by this stage of analysis is a method for characterizing the types of questions (and thus the types of answers) that are posed in a domain, such that any domain can be described by the questions they ask, as in “Domain *X* asks *Y* and *Z* types of questions.”

Dillon’s (1990) theory of the practice of questioning posits that questions can only be understood in relation to the assumptions that precede it and the answers that follow it; furthermore, each is comprised of a “sentence” and the “act of putting” the sentence (p. 131). In other words, questions – as all other linguistic expressions such as declaratives and orders – have both content and form. While *content*, or the *what*, of documents has long been a topic of interest in LIS research in concepts such as document “about”-ness, topical relevance, and subject classification, the *form*, or *how*, has received little attention. In Stage Two, the questions and answers are analyzed for what the domains ask about (question content) and how they ask and answer (question form). The questions are classified according to the dimensions of content and form, briefly described here and in more detail in Chapter Six: Question content and Chapter Seven: Question form.

1. Content – A question is structured as a *query* posed about a *subject*, where the *subject* is an object in the world about which some determination is being made and the *query* is the particular determination; the *subject* expresses the indeterminate situation, while the *query* indicates the type of determination that is being sought. The subjects of dissertation abstracts were inductively coded, guided by the question, “what is this dissertation about, relative to the topic of

‘memory’?” Once the subject codes achieved stability within each domain, the queries were coded deductively using Dillon’s (1984) classification of research questions (see Table 25) relative to the subjects. Each domain was analyzed singly, for patterns of query-subject pairings, and comparatively, for differences in query-subject pairings between domains.

2. Form –The concept of the epistemic form of the question was developed for the current investigation. Epistemic question forms are structures that show how inquiry is organized. Epistemic forms were inductively coded, guided by the question, “What is the organizing structure by which the memory-related question content is being presented?” Each domain is analyzed singly, for its epistemic forms, and comparatively, for differences between domains’ use of forms.

The theoretical proposition that is being tested is whether knowledge domains can be differentiated by question categories of content and form. Stage Two simultaneously tests this proposition and develops the faceted typology of research questions according to content and epistemic form. The products of this stage of analysis are: a method for categorizing questions according to content and form; a question profile, consisting of the different question categories, of each domain’s research about “memory” from 2006 to 2011; and a picture of the different questioning approaches that three domains take towards “memory” as an object of research.

Stage 3 utilizes the question categories to explore the relation between question type and domain assumptions related to the nature of knowledge production.

**4.4.3 Making visible questions' assumptions (Stage 3).** Having identified the question categories and produced domain question profiles in Stage Two, the goal of the Stage Three analysis is to compare the Stages One and Two findings, the dissertation abstracts, and a sample of full text dissertations of differing question categories in order to make visible the assumptions that precede the question formulations, thus relating the communicative function and logical structure of the question formulations to the assumptions of inquiry. Building on the comparison of domains according to question categories, here the comparison is of the question categories themselves, along the two facets of content and form, for their assumptions. Each question category that emerges in Stage 2 will represent a case for comparison, with the data for analysis including the results from Stages 1 and 2, abstracts, full text of dissertations, interviews with authors, and subject domain literature, as is deemed necessary for the understanding of ontological and epistemological issues. The data will be coded on a case-by-case basis for assumptions related to “memory” as a topic for inquiry.

Together, the coding of Stages Two and Three constitute the combined use of two approaches to qualitative data analysis, occupying the top left quadrant of Glaser and Strauss' (1967) typology (Table 10). Stage Two employs the first approach, coding the data first, according to an explicit coding procedure, for question content and form, then analyzing the data against the provisional hypothesis that different domains ask different kinds of questions. Stage Three adheres to the second approach, inspecting the data for new properties or sub-categories of the theoretical categories, in this case, the categories of inquiry-related assumptions.

<i>Generating Theory</i>	<i>Provisional Testing of Theory</i>	
	Yes	No
Yes	<b>Combining (2) inspection for hypotheses along with (1) coding for test, then analyzing data</b> (4) Analytic induction	(2) Inspection for hypotheses
No	(1) Coding for test, then analyzing data	(3) Constant comparative method Ethnographic description

**Table 10. Use of approaches to qualitative analysis (Glaser & Strauss, 1967, p. 105)**

The constant comparative method attempts to forge a third way by applying the systematic analytical procedures of the first hypothesis-testing coding approach with the sensitivity to theory development of the second approach. The current study combines the first and second approaches on the basis of the theoretical framework of domain analysis and erotetic theory, which suggests certain hypotheses to be tested about the relation of question formulations to domain assumptions, but also leaves room for the development and refinement of the existing theory of questions, particularly from the social epistemological perspective of knowledge domains rather than the cognitive linguistic viewpoint.

#### **4.5 Conclusion**

The three-stage study, guided by the methodological principles of a comparative domain analytic approach, seeks to determine whether domains are unique in their question formulations, how the different questions can be characterized along the dimensions of content and form, and what the question categories indicate about domain answers and assumptions related to “memory.” The research design hinges on comparison of domain research on a common topic in order to discern differences in what and how domains ask, and what and how they answer. These comparative differences

make visible the assumptions of the question, which are instrumental in understanding the domain-based nature of inquiry.

The methodology developed in this chapter is intended to be applicable to all scholarly domains. Stages One and Two are suitable for creating question profiles for any single scholarly domain, while Stage Three is applicable to the comparison of any number of domains. The results of the later stages hinge on those of Stage One, which produces the question formulations that are the basis for analysis in later stages. The following chapter, Chapter Five: Method for identifying domains' question formulations, details the development and application of the method.

## CHAPTER 5: METHOD FOR IDENTIFYING DOMAINS' QUESTION FORMULATIONS

### 5.1 Introduction

All knowledge is the product of inquiry, yet little scholarly attention has been given to questions as a tool of inquiry. This dissertation considers whether and how scholarly domains can be characterized by their questions, and what the differences between domains' questions indicate about the answers that follow and the assumptions that precede the questions. The study of scholarly domains' questions poses a significant challenge, whether seeking to characterize a single domain or compare two or more domains. For a single domain, the main difficulty is that questions are almost never directly stated in interrogative form in the knowledge products resulting from inquiry. Additionally, comparison between domains demands some method that cuts across the special languages, vocabularies and norms of communication that accompany distinct domains. What is needed is a method to systematically identify questions from the products of domain inquiry in an accurate and consistent manner in order to build a foundation of validity and reliability for the analysis that takes these questions as a primary data source.

This chapter describes the development of a method for identifying domains' question formulations from domains' knowledge products and demonstrates its application towards identifying the question formulations of ninety-seven dissertations abstracts about "memory" in neuroscience, literature, and computer engineering. While the method was developed for the analysis of scholarly dissertation abstracts, the

foundation of the method and the method itself will initially be discussed in abstract terms in order to establish the generality of its application to any and all knowledge products of inquiry in any and all knowledge domains.

## **5.2 Knowledge products of inquiry**

For the purposes of this study, inquiry is defined as the determination of indeterminate situations through the asking and answering of questions, with the assumption that inquiry occurs relative to knowledge domains, the social epistemological cultures of knowledge production. Some inquiries take place solely for the individual questioner's benefit and exist internal to the questioner, unknown by or shared with anyone else; these are generally inaccessible to other inquirers and the documentalists tasked with making knowledge products accessible to other inquirers. What is of interest to library and information science (LIS) is inquiry that results in the production of documents, objects, programs, actions, or happenings that embody the knowledge produced by the inquiry. These are the knowledge products of inquiry. Some knowledge products may embody the knowledge produced by the inquiry as a whole, as is the case with books, journal articles, and even abstracts. All of these knowledge products aim to communicate the significance of the entire inquiry. Other knowledge products have a more partial relationship to the inquiry, reflecting some part of the knowledge produced, but not intending to communicate the significance of the entire inquiry. For example, computer engineering research often requires the development of a simulator to simulate the environment within which one is seeking to model an environment. This simulator is a knowledge product, but not one that aims to communicate the entirety of the knowledge produced by the inquiry. It may be more aptly considered a byproduct or tool of the

inquiry. Additionally, some knowledge products, such as new research methods or theories that are produced by the inquiry but not ultimately documented, are essentially abstract and may not take a distinct material shape.

As compared to inquiry in everyday life, scholarly inquiry is more highly structured in terms of its institutional and cultural norms and practices. The production of knowledge, or stated differently, the creation of knowledge products, is one of the primary activities of scholarly inquiry. Scholarly communication relies upon highly ordered means of production, validation, and dissemination of knowledge. For this reason, the context of scholarly inquiry was chosen as the context for developing a method for identifying domains' question formulations from the knowledge products of inquiry, as the highly ordered norms of knowledge production and products are amenable for establishing a baseline understanding of whether and how domains differ by their questions. The knowledge products of scholarly research are diverse in length, substance, form, and function, including products as varied as traditional text-based written products (journal articles, books, conference papers), visual images, audio and video, performances (talks, speeches, artistic performances), objects (blueprints, models, design prototypes), as well as abstract entities (simulations, software, mathematical formulas). The method developed for identifying domains' question formulations potentially applies to of these, but its value is most obvious for the class of written documents that comprise the traditional products of scholarly inquiry – books, journal articles, conference papers, etc. - and thus the main interest of library and information science. Of these, dissertation research was chosen as the focus for this study for several reasons. The dissertation is a knowledge product common to all doctoral students, acting

as an entry test for domain membership. To have a committee of domain members accept the dissertation and grant the doctoral degree is to declare that the dissertation writer is acceptably fluent in the domain manner of inquiry. Additionally, all scholarly domains have a dissertation requirement for obtaining a doctorate, which make dissertations a convenient and rich site for the comparison of multiple scholarly domains.

Identification of the question that represents the inquiry embodied in the dissertation may be obtained from several data sources: analysis of the full text, analysis of the introduction, conclusion, or indexing terms. However, dissertation abstracts were chosen due to their concise nature and the primary role they play in scholarly access. Dissertation abstracts are, in and of themselves, a knowledge product of significant import in that their precise function is to communicate the new knowledge that the dissertation research has to offer, in terms of its significance to the state of existing knowledge in the domain. Scholarly abstracts were chosen as the first type of knowledge product on which to develop and test this method, both for the epistemically structured nature of the abstract as a genre of scholarly communication, and for the common use of the dissertation abstract across all scholarly domains. The purpose of a dissertation abstract is to concisely communicate the new knowledge produced by the dissertation in a manner that maximizes its “findability” by those who would deem it relevant to their own inquiries. As such, it is above all an epistemic document, one that is characterized by its function of communicating and validating the knowledge produced therein.

As an epistemic document, its structural elements are defined by their role relative to the knowledge that is produced by the dissertation. Dissertation abstracts within a domain demonstrate patterns and norms in terms of the presentation of the research by

these structural, or epistemic elements. By identifying the epistemic elements of the abstract, what is apparent is that the elements all either point toward the presentation of the question, or refer back to it. In other words, the question is the element of the abstract that is central to and defining of the other elements; it is the linchpin of the abstract, and presumably of the inquiry itself. The epistemic structure of abstracts is further explored in the analysis of question forms in Chapter Seven: Question form. For the current purpose of developing a method for identifying domains' question formulations, the abstract elements of concern are limited to those that indicate the question and answer.

### **5.3 Question correlates**

The implication of the statement that all knowledge has an indirect question correlate (Hookway, 2008), is that any given knowledge claim implies the question that produced it. Questions and knowledge are reciprocal phenomena; they exist in an interdependent relationship. Yet even in textual knowledge products, which present the process of inquiry and the new knowledge that results from the inquiry, questions are rarely stated outright. The function of knowledge products is to communicate the answer to the question, or the knowledge resulting from the question, not the question itself. It is a testament to the essential status of the question in relation to the knowledge domain that it remains unstated. But as a result, what is required is a method for identifying the question, which is so central to organizing inquiry yet hardly ever considered for its analytical or pragmatic use. A logical philosophical conception of questions informs the development of a method for identifying the questions or question correlates that drive the inquiry, from its knowledge products. The method allows for the questions, whether implicit or explicit, to be extracted from the knowledge products of inquiry in a manner

that preserves the specificity of domains' vocabularies while transforming them into linguistically and logically comparable expressions.

As discussed in Chapter Three, Brožek's (2011) logical conception of questions defines questions according to their communicative function and logical structure. Questions have a special communicative function that distinguishes them from other types of expressions, such as orders and declaratives: "Questions are expressions suitable for communicating experiences consisting of gapped cognitive pictures of the world and the will to fill gaps in them" (p. 53). The experience that is expressed by the question has three factors that motivate the asking of and are expressed in a question: cognitive, incognitive, and volitional. The cognitive factor of the experience expressed by the question is the conviction that there exists an adequate picture of the situation; the incognitive factor indicates a realized indeterminacy in the picture. The volitional factor is the will to resolve the indeterminacy in the picture of the situation. Importantly, while it is an indeterminate picture of reality (the incognitive factor), the picture itself is adequate (the cognitive factor); that is, what constitutes a determinate picture is known. What remains unknown is the information that will transform the indeterminate situation into a determinate one.

To demonstrate the epistemic function of the question to define the indeterminate situation, which is the "known unknown," consider the following example from a neuroscientific dissertation abstract in the current data set. When asking, "What is the role of hippocampal brain rhythms and neural spikes in episodic memory processes?" (N50), what is known is that hippocampal brain rhythms and neural spikes have a role in episodic memory processes; what is unknown is the precise nature of the role.

Juxtaposed, they produce a known unknown: that hippocampal brain rhythms and neural spikes have some undetermined function in the neural mechanisms of episodic encoding and retrieval. Fundamentally, questions express the indeterminate situation that drives inquiry. The will to transform the indeterminate situation into a determinate one is expressed by the asking of the question, or the declarative statement of the intent to answer the question (“This dissertation demonstrates,” “I analyze,” “This thesis concerns,” etc.).

The second aspect of Brožek’s (2011) definition of questions is that they are defined by their logical structure, rather than by their syntactic structure. As relates to structure, there are two types of questions: hypothetive and completive. The structure of completive questions consists of three explicit parts: a question particle (who, what, when, where, why, how), a question mark or its spoken counterpart, and the remainder of the sentence. Hypothetive questions are structurally marked by inversion, or in the case of embedded questions, by the whether- or which- question particle. While a few knowledge products present questions directly, most embed the question in a declarative statement of intent to fill the indeterminate situation. For instance, one dissertation abstract states, “Here, we wanted to further characterize the contribution of Cdh1 to learning and memory at both developmental and adult stages” (N47). While this statement lacks the syntax of a question, it implies a question, which can be expressed by reinserting the volitional element, the invitation to respond. Since the rest of the abstract confirms that this is a completive, open-ended question rather than a hypothetive, closed-ended one, the transformation of the declarative description of intent can be transformed into an interrogative by the re-insertion of the appropriate completive indicative: *who*,

*what, when, where, why, or how.* The only sensible choices are *what-* or *how-*: “What is the contribution of Cdh1 to learning and memory at both developmental and adult stages?” or “How does Cdh1 contribute to learning and memory...?” Considering the presentation of the answer in the abstract, it is determined that the *what-* question is more accurate. By this manner, we can be guided in the formulation of the question correlates implicit in the presentation of knowledge claims in knowledge products.

It is important to note that the question correlate, as derived from the knowledge products, is the “ideal” question in that the researcher poses it to the reader *in full knowledge of the answer*. In this way, the current treatment of the question differs from the cognitive investigations of question formation and negotiation in the information search process, in which questions are manifestations of the searchers’ cognitive state of knowledge in relation to the topic throughout the inquiry process (Kuhlthau, 1992). The “ideal” question is, admittedly, static in nature, as it is formulated as a perfect inversion of the answer, post-inquiry. But by this conception, the question paradox is unraveled: questions do require that one knows what one does not know. One must know the manner in which the situation is indeterminate. For this reason, knowledge products such as scholarly publications, which present results of completed research, are ripe sources of data for the initial establishment of a social epistemological theory of questions. In contrast, one can think of the concept of a “working” question and its multitudinous iterations as snapshots of either the scholar’s changing focus or increasingly refined understanding of the research being undertaken. Research documents that reflect the working question, such as dissertation proposals, research journals, memos, and reports, have much to reveal about the relation of the individual questioner to the domain, but the

finished product is the better source for understanding questions in relation to knowledge domains. A conception of the question as having a distinct communicative function and logical structure allows for a consistent approach to characterizing the knowledge products of a domain or multiple domains.

#### **5.4 Description of method**

The method for identifying questions from the knowledge products of inquiry developed organically en route to the characterization and comparison of scholarly domains according to their question formulations about the topic of “memory.” Two principles were held in tension in the development and application of the method: (1) to stay as close to the special languages and vocabularies of the domains, making adjustments to the presented question as needed only for the sake of clarity and consistency across the sample, and (2) to select the question that most precisely communicates the known unknown from its myriad potential variants. In cases where the sample is narrowly defined, such as when confined to a highly specific topic in which domain inquiry is united in its focus and methods – having a high degree of strategic dependence and low degree of strategic task uncertainty, in Whitley’s (2000) typology – the tension between the two principles is likely low, as compared to the comparison across disparate and diversely structured domains, in which case the tension may be high.

The method consists of four sequential steps that can be applied to any sample of knowledge products, whether of a single domain or multiple domains.

1. Choose the sample of knowledge products – The sample of knowledge products, in type, number, and domain affiliation, should reflect the social epistemological context of interest. The choice to sample from a single domain at a point in time

or over a period of time, multiple related domains, multiple highly contrasting domains, or multiple domains on a common topic corresponds to the depth and breadth of focus that the corresponding analysis will have.

- a. Type of knowledge product – The choice of what type of knowledge product to analyze has a direct relation to the questions that will be identified from the knowledge products. Analysis of entire books will produce different questions than its individual chapters; photographs of objects will produce different questions than written descriptions or the objects themselves.
  - b. Sampling frame and size – The size, depth, and breadth of the sample will also have an effect on the questions and answers identified. While a single knowledge product can be subjected to the method, it is better applied to coherent samples that attempt to represent a sub-domain, domain, or multiple domains, due to the assumption that questions are social epistemological tools and meant to be interpreted in relation to knowledge domains. The more narrow the sample, the more the questions and answers will reflect subject expert knowledge. The broader the sample, the more the questions and answers will reflect a meta-perspective on the domain or domains.
2. Familiarization with the sample – Familiarization with the knowledge products in their entirety, whether through reading, viewing, or otherwise engaging with them as dependent on their modality (textual, audio/visual, experiential, etc.), is the priming stage for identification of the questions. The goal of this stage is to gain

a general familiarity with the structures and semantics of the knowledge products, which provides context for the identification of the question- and answer-indicative segments in Step 3.

3. Identification of question and answer-indicative segments – Identification of the abstract segments that are indicative of the questions driving inquiry or the answers produced by the inquiry are coded as “question” and “answer,” respectively. For written knowledge products, code-able segments can be as small as a sentence phrase or span many pages of text. Other types of knowledge products (audio/visual products, tools or instruments, actions, etc.) will require individualized determinations of what constitutes a code-worthy unit. This step is essentially one of data reduction (Miles & Huberman, 1994), in which the non-question/answer-indicative parts of the knowledge product are eliminated in order to see the question and its answer more clearly. The principle of coding should tend towards inclusion of potentially relevant information at the beginning of this process, then towards leaner coding as the epistemic structures of the knowledge product (relation between informative segments and question/answer) begin to emerge. The question and answer-indicative segments are identified on an iterative basis until stability is achieved in the sample.
4. Formulation of the question – Formulation of the questions begins with those abstracts with easily identifiable questions, requiring little-to-no manipulation of the coded segments, and proceeds in stages to those requiring increased manipulation and interpretation of the knowledge product as a whole. The guiding principle is to stay as close to the language of the knowledge product as is

possible. Identification of the questions is conducted, in iterative manner, for the entire sample of knowledge products, adjusting language or syntax as necessary to reflect the relation of the individual knowledge products to the whole sample.

By this method, the knowledge products of a domain or domains can be approached in a manner that is consistent in regards to the theoretical conception and empirical identification of the questions that drive inquiry and the answers that are produced in reply to the questions, as embodied in the knowledge products of the inquiry. At the same time, the method is inherently flexible in that the level of specificity and contextual nuances of the questions are dependent on the sample. A sample of knowledge products from a narrow sub-field of the domain will engender a highly subject-specific characterization of questions, while a sample across the entire domain will produce a more domain-general characterization of questions. Comparison across several domains will produce an even broader characterization of questions. It follows that a single knowledge product may be represented by a limitless number of variations of questions in a limitless number of sampling scenarios. This does not reflect a lack of reliability; rather it is a measure of validity that reflects the meta-epistemological perspective of knowledge organization. Knowledge products have no single, essential question, but limitless variations depending on the social epistemological context in which they are being located.

### **5.5 Application of method to the scholarly research on “memory”**

The method that is described in general terms above is now described in the context in which it was developed: the analysis of 97 dissertation abstracts in neuroscience, literature, and computer engineering on the topic of “memory.” The first

step of the method for identifying questions and answers from the knowledge products of inquiry is the selection of the sample for analysis. Since the interest is in characterizing domains according to the questions they ask, the sampling frame is dissertation research on “memory” over a five-year period (2006 to 2011). ProQuest Dissertations and Theses Database was searched for dissertations with “memory” appearing as a keyword, in the title, or in the abstract, returning 420 results. Three of the top four highest producing domains were chosen for comparison, resulting in a sample of 97 dissertation abstracts after weeding out those not centrally about “memory”: 57 in neuroscience, 20 in literature, and 20 in computer engineering. The abstracts were read in their entirety numerous times, domain by domain, until a general familiarity was achieved with the language and structure of the abstracts (Step Two). Steps Three and Four of the method were then applied to each domain subset.

Step Three is the identification of question and answer-indicative abstract segments. Initial attempts to identify the questions representative of the dissertation inquiries resulted in several observations about the tacit nature of questions in scholarly abstracts and the mutually defining status of the question and the answer. Interrogative questions (statements marked by the use of question indicatives (wh- words) and ending in a question mark, or the use of inverted grammar) are rarely present. In many cases, the question is stated as a declarative: “This thesis seeks to explore...” “I will show...” “This research considers...”. In some cases, the question is only implied in descriptions of the research design or methodology. The answer is often more easily identified than the “question.” It is recognizable in its presentation as the “findings,” “results,” or new knowledge that is produced by the inquiry. In fact, the question is sometimes only

recognizable as an inversion of the answer. These observations suggested a multi-staged process of identifying the questions from the abstracts, starting with those most easily identified and requiring little transformation, and progressing to successive stages according to the type and level of transformation involved (Step Four).

**5.5.1 Neuroscience.** The question- and answer-indicative segments were identified by a process of data reduction. The segments of the abstracts that are not directly indicative of the questions or answer were eliminated, such as those describing the motivation or background of the research problem or explanations of the research design and methods, leaving only the segments that pertained to the question and its answer. What remains is, essentially, the question and answer summary of the inquiry.

Table 11 illustrates this step.

Code	Abstract
N27	The behavioral and neural effects of emotion regulation on autobiographical memory retrieval
Question	Individuals' short- and long-term goals can influence the constructive nature of autobiographical memory recall. The overarching aim of this dissertation was to examine how emotion regulation goals in particular might modulate autobiographical recall at both a behavioral and neural level. In Chapter 1, a new behavioral task instructed individuals to cognitively reappraise the emotions associated with negative and positive events. Results revealed that such emotion regulation goals influence the emotional and other subjective experiences associated with recall, such that up-regulation instructions were linked to greater reported levels of emotional intensity, sensory detail, and recollection (e.g., reliving), and vice-versa for down-regulation instructions. In Chapter 2, functional magnetic resonance imaging (fMRI) was used as participants were instructed to decrease, increase, or maintain the emotions associated with negative autobiographical events. Decreasing emotional intensity primarily engaged neural activity in regions previously implicated in cognitive control (e.g., dorsal and ventral lateral prefrontal cortex), emotion generation and processing (e.g., amygdala, insula), and visual imagery (e.g., precuneus) during an early phase of recall as participants searched for and retrieved events. In contrast, increasing emotional intensity engaged similar regions as individuals prepared to recall negative events (i.e., before a memory cue was presented) and again as they later elaborated upon the details of the events they had recalled. In Chapter 3, individual differences in habitual use of cognitive reappraisal were measured and their relation to neural activity during autobiographical recall was examined. Results revealed that, even when not explicitly instructed to reappraise, habitual use of reappraisal was broadly associated with neural activity in cognitive control regions (e.g., dorsal and ventral lateral prefrontal cortex, dorsal anterior cingulate cortex) as well as emotion processing regions (e.g., amygdala, insula) across memories that varied in their emotionality and specificity. Taken together, these results suggest that short- and long-term emotion regulation goals can influence the construction of autobiographical memories on both behavioral and neural levels.
Answer	
Answer	

	<b>Table 11. Neuroscience: Identifying question- and answer-indicative segments</b>
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The reduced portions of the abstract indicate the current state of knowledge on the topic, the research design and methods, and the findings of the individual studies that comprise the dissertation as a whole.<sup>9</sup> These abstract elements, or inquiry components, will be further analyzed and utilized in Chapter Seven to identify the epistemic form of the question. A general rule of thumb for identifying the question- and answer-indicative segments is to ask, “Does this tell me what the inquiry is about?” If so, it pertains to the question. The segments indicating why the research is being undertaken, or how it is carried out, inform about the nature of knowledge production in the domain but are not essential to identifying the question. The identified question is also compared to the dissertation title, to consider whether it reflects the dissertation author’s own conception of what the inquiry is “about.”

Once the question and answer- indicative segments were identified, the identification of questions proceeded from the simplest cases to the most complex, from those requiring little-to-no syntactical transformations, to those requiring more manipulation. As expected from preliminary readings of the abstracts, in no cases was the question directly stated in interrogative form. In thirty-six of the fifty-seven abstracts, identification of the question entailed turning a declarative statement of the researchers’ intent or statement of the research problem into an question through the inversion of sentence grammar (Table 12).

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<sup>9</sup> Consideration was given as to whether to characterize the dissertation as having a single question and answer or to identify a separate question and answer for each of the three studies that comprise this dissertation. Since the sample is a broad, comparative sample of memory research, it was decided that the broader question, as informed by the individual studies and results, was more appropriate.

ID	Abstract segment	Question
N47	Here, we wanted to further characterize the contribution of Cdh1 to learning and memory at both developmental and adult stages.	What is the contribution of Cdh1 to learning and memory at both developmental and adult stages?
N1	Using Hebb's theory of neuroplasticity and the principle of automaticity as theoretical bases, this experimental study examined the effectiveness of a specific 12-week neuroscience-based, cognitive-skills computer-training program on the cognitive processing of 40 elementary students in grades 2-4 with SLD.	Whether cognitive processing differs between an experimental group of elementary students in grades 2-4 with specific learning disabilities (SLD) receiving a 12-week neuroscience-based and a control group

**Table 12. Neuroscience: Transforming declarative statements of researcher intent into questions**

N47 states the intention of the inquiry as, “Here, we wanted to further characterize the contribution...” which is transformed by inversion and the insertion of the question indicative, what-, into “What is the contribution...?” The transformation of N1, a hypothetive question, undergoes essentially the same transformation (inversion and insertion of a question indicative, whether-), but the syntax is additionally adjusted. The indirect whether- formulation is chosen in order to maintain consistency and ease of presentation of hypothetive questions, whose direct variants may begin with “Is...?” “Do...?” “Does?” etc.

In erotetic theoretical terms, these transformations reinsert the volitional aspect that characterizes the communicative function of questions according to the logical structure of completive or hypothetive questions. The statements are transformed from declarations of the intent to resolve an indeterminate situation, to invitations to resolve an indeterminate situation. The formulated question is checked against the identified answer segments, to ensure that the question accurately represents the indeterminate situation that is resolved by the answer. A full list of the questions formulated in this manner and the questions and the abstract segments from which they were derived are included as Appendix B.

Of the remaining ten abstracts in the sample that do not declare the researchers' intent, in six cases the question is implied by the presentation of the answer. The principle that all knowledge has a question correlate (Hookway, 2008) justifies the inference of the question from the presentation of the answer.

ID	Abstract segment	Question
N54	One hypothesis that has been proposed to account for these inconsistent findings is that the response of some brain regions subserving working memory (WM) task performance to parametrically increasing WM load, most critically dorsolateral prefrontal cortex, may in fact be non-monotonic in nature; that is, at sufficiently high loads activation in these regions may begin to decrease.... To date, this hypothesis has not been directly tested; however, I report here the results of a series of studies using the self-ordered working memory task that clearly demonstrate such an 'inverted-U' in healthy participants that is absent in patients with schizophrenia.	Whether healthy patients demonstrate an "inverted-U" response to the self-ordered WM task that is absent in patients with schizophrenia.

**Table 13. Neuroscience: Inferring questions from answers**

Table 13 shows an example of the identification of a question correlate from the presentation of the answer. In this dissertation, an existing hypothesis, that patients with schizophrenia lack the "inverted-U" pattern of neural activity of healthy patients, is put to the empirical test. As with the hypothetive question in Table 12, the question is formed by inverting the sentence grammar, inserting a question indicative (whether-), and adjusting the syntax of the question to conform to the consistent presentation of hypothetive questions in the sample.

Finally, the questions of the twelve remaining abstracts in the sample are most clearly indicated in the title of the dissertation. The example in Table 14 demonstrates this type of transformation.

ID	Abstract segment	Question
N6	Title: The role of the atypical Protein Kinase C zeta orthologue, PKC Apl III, in synaptic plasticity and long term memory in <i>Aplysia californica</i>	What is the role of the atypical Protein Kinase C zeta orthologue, PKC Apl III, in synaptic plasticity and long term memory in <i>Aplysia californica</i> ?

**Table 14. Neuroscience: Inferring questions from titles**

In these cases, transformation of the title produces the most concise and complete question correlate, as compared to the other abstract segments such as presentation of the research design or answer. Hjørland and Albrechtsen (1995) propose that the information value of different subject access points such as titles, abstracts, citations, descriptors, or words from full-text records is relative to the domain. That the question can be identified solely by the title for these twelve abstracts indicates that neuroscience places a high informational value on the title as a subject access point.

Overall, the neuroscience abstracts largely present declarative statements of researchers' intent, which are transformed into questions by the appending of question particles or syntactic inversion. When there is no declarative statement from which the question can be formulated by reinserting the volitional factor, the question correlate of the answer can be identified, or inferred, from other elements of the abstract.

**5.5.2 Literature.** While the language and style of literature abstracts differs markedly from neuroscience abstracts, the underlying epistemic structure is quite similar. Identification of the question- and answer-indicative segments for the twenty literature abstracts follows the basic procedure that was applied in the neuroscience sample. The abstract segments related to description of the topic, theoretical influences, and methodological approaches – anything related to *how* or *why* the inquiry is being conducted – were eliminated in order to reduce the data to the question- and answer-indicative segments (Table 15).

Code	Abstract
L20	The crónista (re)writes the nation: Memory and "alternative histories" in crónicas of Mexican centennial and bicentennial commemorations of independence
Question	This study examines the relationship between the Latin American journalistic crónica

Answer	<p>("chronicle") and memory, specifically the way writers used highly imaginative crónicas as a means to uphold or challenge official memory and history and to propose "alternative" readings of the nation during Mexico's centenary and bicentenary commemorations of Independence of 1910, 1921, and 2010. The centenarios were times when historical memory was of paramount importance and that foregrounded two long-standing obsessions of the crónica: the topic of national identity and an interest in great historical events. Positing the crónica as a sort of literary lieu de mémoire ("site of memory"), the study analyzes works from Mexican and Mexican American cronistas ("chroniclers") drawn from current and turn-of-the-century periodical sources including writings by Juan B. Urrutia, "Cagliostro," Rafael López, José D. Frías, José de Jesús Núñez y Domínguez, Jorge Ulica (Julio G. Arce), Carlos Monsiváis, Rafael Pérez Gay, and Hermann Bellinghausen. The study contends that the modern crónica (1910, 1921) and the postmodern crónica (2010) as works of memory differ in their literary treatment of events, partly due to the changing role of the cronista as well as changes in the form/content, functions, and reception of the literary chronicle from one century to the next. In the case of the Mexican independence celebrations examined here, "alternative histories" or narratives of the nation's past also responded to changes associated with the paradigmatic shift from modernity to postmodernity. While for turn-of-the-century modernista writers, for instance, the crónica itself was an experiment in creative journalism, crónicas today, often published in blogs, or online journals or newspapers, involve new forms of experimentation, are not necessarily published by professional writers or intellectuals, and may involve reader participation (or "modification" of official memory through online commentary and social networking tools). Furthermore, while nineteenth-century crónicas sought to express a singular, monolithic version of national identity, now postmodern or late twentieth and early twenty-first century cronistas tend to question such metanarratives or "all-encompassing" explanations of knowledge or "absolute truths". Today's cronistas also seem less likely to function as an authoritative source of knowledge (or "memory"), as readers now have the ability to quickly and easily verify information on their own (via the internet) and to interact with electronically published texts to question them or to provide their own versions of "what happened"; that is, to provide counter-memories. Critical studies to date have been unable to provide a definition of the literary crónica that accounts for diachronic changes as well as issues relating to the genre's formal hybridity (between literature and journalism) or its official or unofficial stance toward state-backed concerns. I argue, however, that reading the crónica as memory transcends these questions and provides an important bridge to a more all-inclusive definition of the genre, thus establishing its significance in the literary canon and offering an additional approach to its critical study.</p>
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**Table 15. Literature: Identifying question- and answer-indicative segments**

In the example in Table 15, the question-indicative segment is the first sentence of the abstract, which begins by introducing the topic ("the relationship between the Latin American journalistic crónica ("chronicle") and memory") and the focus of the inquiry: "the way writers used highly imaginative crónicas as a means to uphold or challenge official memory and history and to propose "alternative" readings of the nation during Mexico's centenary and bicentenary commemorations of Independence of 1910, 1921, and 2010" (N20). The answer-indicative segment comprises the bulk of the remainder of

the abstract. While there is more variation in length, style, and level of specificity and thoroughness of literary abstracts than in neuroscience, the question and answer-indicative segments are easily identifiable, in relation to each other and in response to the question of what the inquiry is about, throughout the sample.

Having identified the question and answer-indicative segments of the literature abstracts, the questions can be identified from these segments. In one rare case, the question is actually stated outright as an interrogative (Table 16).

ID	Abstract segment
L15	How does a woman writer memorialize her own traumatic history, when it happens to be part of a larger History dominated by male narratives (as far as Holocaust and slavery go), or when it is altogether silenced (as is the case for madness and institutionalization)?

**Table 16. Literature: Identifying explicitly stated questions**

This is the single instance in the three-domain sample in which the question is actually directly stated in logical form, requiring no transformation of any kind. More commonly, the question is identified by inversion of the thesis statement (Table 17). This is a simple syntactic transformation of the declarative expression into an interrogative one.

ID	Abstract segment	Question
L1	This thesis will provide a comparative analysis of the poetics of traumatic hindsight and the literary devices that three texts--Anne Michaels's <i>Fugitive Pieces</i> , Linda Hogan's <i>Solar Storms</i> , and Toni Morrison's <i>Beloved</i> --utilize to signify the necessity of a retrospective gaze towards the atrocious past.	What are the poetics of traumatic hindsight and the literary devices that three texts--Anne Michaels's <i>Fugitive Pieces</i> , Linda Hogan's <i>Solar Storms</i> , and Toni Morrison's <i>Beloved</i> --utilize to negotiate the fragmentation that characterizes the traumatic aftermath and signify the necessity of a retrospective gaze towards the atrocious past?
L3	This dissertation analyzes how these women writers use various aesthetics in portraying the landscape of memories to represent, redefine, and transcend repetition, trauma, and loss, and to renegotiate the reality of the past, present, and future.	How do Marguerite Duras (1914-1996), Eileen Chang (1920-1995), and Maxine Hong Kingston (1940-), women writers who share transnational experiences and express various types of traumatic loss in their works, use various aesthetics in portraying the landscape of memories to represent, redefine, and transcend repetition, trauma, and loss, and to renegotiate the reality of the past, present, and future?

**Table 17. Literature: Inferring questions from declarative statements of researcher intent**

Fifteen of the twenty literature dissertations' questions are identified by this type of transformation. The declarative statement of researcher intent is transformed into an interrogative, with minimal change to the original segment (L1), by reinserting the volitional element through inversion. When necessary, details are extracted from elsewhere in the abstract in order to make the question completely self-sufficient, as when a reference to "these women writers" in the original abstract is replaced with the specific women writers' names and their shared characteristics (L3).

The question in L14 is formulated by translating the title of the dissertation into an interrogative statement (Table 18).

ID	Abstract segment	Question
L14	Title: Remembering Modernity: Techniques of Temporal Memory in Twentieth-Century Literature and Film	What are the techniques of temporal memory in twentieth-century modernist and post-modernist literature and film?

**Table 18. Literature: Inferring questions from titles**

In this case, as with the neuroscience example in Table 14, the abstract does not offer a singular clear statement of what the dissertation is about, but the title is judged to encompass the entirety of the answer that is presented in the abstract. This dissertation stands out in comparison to the rest of the dissertations as producing literary theory where the others produce literary criticism. The level of difficulty in identifying the question may represent a division with the domain, between theoretical and critical dissertations, or it may simply be a product of the individual scholar's writing style that emphasizes the theoretical approach over the critical findings.

The identification of the questions driving the production of creative writing dissertations demands special attention, as creative writing is not typically considered a

type of question-driven scholarly inquiry. While this issue will be taken up in more detail in other chapters, what is of interest to the current chapter is that the three creative writing dissertations distinguish themselves from the rest of the sample by the level and type of difficulty in identifying their questions (Table 19).

ID	Abstract segment	Question
L7	The dissertation explores the specific memories of the protagonist, Bradley Scott. However, at a deeper level of abstraction it is about a collective memory and how we as humans and creative artist continue to grapple with, and attempt to reorder, our memories.	What is the nature of memory (individual vs. collective)? How do we as humans and creative artist continue to grapple with, and attempt to reorder, our memories?
L16	Veiled Men is about a woman's struggle to regain her sense of belonging, having lost her memory after being injured in a violent attack. The focus of the novel involves the collectivity of memory and the way patriarchal culture ignores and ultimately punishes women's anger and desire?	What is the nature of memory (individual vs. collective)? How does patriarchal culture ignore and ultimate punish women's anger and desire?
L17	Creatures after Their Kind is a collection of six short stories that explores the importance of myth, memory, tradition, and place within a Southern context.	What is the importance of myth, memory, tradition, and place within a Southern context?

**Table 19. Literature: Inferring questions from declarative statements of “about”-ness**

The creative writing dissertations’ abstracts are a combination of plot summary, description of literary technique, and identification of literary influences. The questions are notably broad, in relation to the other literature questions. The works are “about a collective memory” (L7), or involve “the collectivity of memory” (L14), or importance of memory in the South (L17). In relation to these broad characterizations of memory, the question is equally broad. If the answer is that memory is collective, then the nature of the indeterminate situation that it seeks to resolve is not “what is memory,” but “what is the nature of memory – is it individual or collective?”

In summary, the questions of the majority of the literature abstracts are identified through a transformation of declarative statements of researcher intent into interrogatives. Where there is less clarity, the conception of the question as having a communicative function of expressing a indeterminate situation is more heavily leaned upon to identify

the nature of the indeterminacy. A full list of the formulated questions and question and answer segments from which they are derived literature abstracts is found in Appendix B.

**5.5.3 Computer engineering.** The computer engineering abstracts are highly consistent in their epistemic structure, generally comprising three elements: a detailed explanation of the background and significance of the memory-related problem (why the inquiry is being conducted), statement of the problem and solution (what the inquiry is about), and explanation of the design solution (how the question is answered). The reduction of the twenty computer engineering abstracts down to question and answer-indicative segments required elimination of the why and how, leaving the what – the question and answer-indicative segments – from which the question can be extracted (Table 20).

Code	Abstract
CE2	Providing Fast and Safe Access to Next-Generation, Non-Volatile Memories
Question	Emerging non-volatile memory technologies such as phase change memory, spin-torque transfer memory, and the memristor, will provide many orders of magnitude decrease in latency compared to disk and flash memory, dramatic increases in bandwidth, and a byte-addressable interface similar to DRAM. These new memories will offer enormous performance gains and intuitive abstractions for storage, but fully realizing these benefits requires us to rid software of disk-centric optimizations, design decisions, and architectures that limit performance and ignore bottlenecks previously hidden by the poor performance of disk. The algorithms that storage and database systems use to enforce strong consistency guarantees are critical to performance, and current solutions are deeply tied to conventional disk technology. This dissertation addresses the problem of providing transactional support for fast, non-volatile memories that exploits their raw performance and makes programming easy.
Answer	First, we present a prototype PCI-based storage array that targets fast, non-volatile memories and provides hardware support for multi-part atomic write operations. Multi-part atomic writes atomically and durably commit groups of writes to storage. Unlike previous approaches for flash-based SSDs, multi-part atomic write support makes logging scalable and transparent, providing a strong foundation for flexible ACID transactions. Using multi-part atomic writes, existing transactions mechanisms such as ARIES-style write-ahead logging can be redesigned to make optimal use of these memories, providing up to 3.7× the performance of the baseline version of ARIES. Second, we address the problem of providing strong consistency guarantees for storage that is directly accessible via the processor's memory bus. We present NV-heaps, a persistent object store which provides a familiar programming interface and protects against application and system failures by avoiding familiar programmer errors as well as new errors that only arise with persistent objects. Compared to Berkeley DB and Stasis, two persistent object stores designed for disk, NV-heaps improves performance by 32× and 244×, respectively, for operations on a variety of persistent data structures. To further improve safety, we present programming language support for NV-heaps. We introduce a
Answer	

	Java-like language that provides the features NV-heaps require, along with a new static dependent type system that enforces the invariants that make NV-heaps safe.
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**Table 20. Computer engineering: Identifying question- and answer-indicative segments**

The first few sentences of CE2 describe the significance of the inquiry in terms of the memory-related obstacles to computer performance based on forecasted trends in computer technology. Next, the abstract states the broad dissertation-level problem emerging from the forecasted trends, “the problem of providing transactional support for fast, non-volatile memories that exploits their raw performance and makes programming easy.” The problem is addressed in three answer-indicative segments, corresponding to a three-part design solution to the problem.

In five dissertation abstracts, including the example above, the question-indicative abstract segment is a declarative statement of researcher intent or belief, similar to the majority of dissertations in neuroscience and literature (Table 21).

ID	Abstract segment	Question
CE3	This dissertation addresses the problem of providing transactional support for fast, non-volatile memories that exploits their raw performance and makes programming easy.	How can transactional support be provided for fast, non-volatile memories that exploits their raw performance and makes programming easy?

**Table 21. Computer engineering: Inferring questions from declarative statements of researcher intent**

In CE3, “the problem of providing...” is action-oriented, to which the question is a *how*-question – how can it be done? These declarative statements are transformed into interrogative questions by inverting the grammatical structure of the sentence, with the use of the *how*- marker for declarations of actions and use of the *what*- marker for declarations of objects.

Two abstracts have declarative statements of researchers' intent, but require additional information from the description of the research problem in order to configure the question to be comprehensible on its own (Table 22).

ID	Abstract segment	Question
CE1	For example, NAND SSDs have excellent random read latency; however, they have a relatively slow random write performance. This means that any architecture utilizing these devices should leverage their desirable features while hiding their drawbacks. The primary focus of this work is on how NAND SSDs should be integrated into the memory hierarchy. This work therefore proposes an architectural approach tailored to mitigate the SSD drawbacks while leveraging their performance advantages.	What memory architecture integrates NAND SSDs into the memory hierarchy in a manner that mitigates the drawbacks of NAND SSDs (relatively slow random write performance) while leveraging their performance advantages (excellent random read latency)?

**Table 22. Computer engineering: Inferring questions from declarative statements of researcher intent in context**

In CE1, the problem statement, that “The primary focus of this work is on how NAND SSDs should be integrated into the memory hierarchy,” is combined with information from the preceding context (the characteristics of NAND SSDs) and following solution statement (an architectural approach to mitigate drawbacks while leveraging advantages) to produce the question in its most detailed form.

Nine dissertations have no declarative statement of the researchers' intent, but imply the question in the answer-indicative segment (Table 23).

ID	Abstract segment	Question
CE18	In this dissertation, we study every major element of the memory system--the memory chip, the processor-memory channel, the memory access mechanism, and memory reliability, and identify the key bottlenecks to efficiency.	What are the key bottlenecks to efficiency of the memory system?

**Table 23. Computer engineering: Inferring questions from answers**

In these dissertations, the declarative statement of the answer is transformed into an interrogative question by identifying the question correlate to the cognitive indeterminacy implied by the presented answer. As with the previous subset, action-oriented declarations are responses to how- questions, while object-oriented declarations are responses to what- questions. From the declaration that “we study every major element

of the memory system... and identify the key bottlenecks to efficiency ” (CE18), the question is identified as, “What are the key bottlenecks to efficiency?” The object-oriented declaration corresponds to a what- question.

For four abstracts, the identification of the questions requires the juxtaposition of the introductory description of the research problem and the answer-indicative segment (Table 24).

ID	Abstract segment	Question
CE20	<p>P: The emerging Phase Change Memory (PCM) technology is drawing increasing attention due to its advantages in non-volatility, byte-addressability and scalability. It is regarded as a promising candidate for future main memory. However, PCM's write operation has some limitations that pose challenges to its application in memory. The disadvantages include long write latency, high write power and limited write endurance.</p> <p>A: In this thesis, I present my effort towards successful application of PCM memory</p>	How can PCM memory, given its long write latency, high write power and limited write endurance, be successfully applied?

**Table 24. Computer engineering: Inferring questions from problem statements and answers**

In CE20, the answer-indicative segment (“A”) suggests that the question is “How can memory be successfully applied?” The definition of “success” is identified in the abstract segment that introduces the research problem (“P”) in relation to the known limitation of PCM’s write operation: long write latency, high write power, and limited write endurance. The resulting question combines the information from both in a single interrogative that describes the indeterminate situation that is driving inquiry.

In summary, the question formulations in computer engineering abstracts are more implicit than those of neuroscience and literature, generally requiring more manipulation than the simple transformation from a declarative statement of researcher intent to an interrogative. Abstracts are mostly focused on the description of the memory-related problem and the proposal and validation of the solution, from which two

elements the question is identified. A full list of the questions and the abstract segments from which they are derived are found in Appendix B.

## **5.6 Conclusion**

In seeking to characterize domains by their question formulations, a method was developed for identifying the question formulations implicit in the knowledge products of inquiry. While the method was developed for the scholarly abstract, it is intended as applicable to other knowledge products and non-scholarly knowledge domains, albeit with greater effort due to the likelihood of greater ambiguity, particularly for non-linguistic knowledge products and the products of artistic fields, such as music, art objects, and performances. Identifying the questions from neuroscience, literature, and computer engineering abstracts describing dissertation research on “memory” was, overall, a straightforward process once familiarization with the domain subsets was achieved. This speaks to the epistemic efficacy of the abstract as a knowledge product of scholarly inquiry and tool of scholarly communication, that presentations of the inquiry produced clear patterns, to the extent that deviations from the relative norm are identifiable and able to be mapped to the epistemic elements by which the abstracts present the results of the inquiry.

The development and application of this method for identifying the questions presented in knowledge products fulfills the first research question, which asks, “What questions do the knowledge domains of neuroscience, literature, and computer engineering formulate about the topic of “memory?” The questions, analyzed in the context of the entire abstracts, form the main source of data for the analysis in Stage Two. Chapter Six analyzes the content of the domains’ questions about memory, what they ask

about memory, and how the content of the question indicates what constitutes an answer. Chapter Seven analyzes the epistemic forms in which the domains' questions are presented and what question form conveys about how to answer. In this manner, the method and work of this chapter form the foundation of the analyses and discussions comprising the remaining chapters of the dissertation.

## CHAPTER 6: QUESTION CONTENT

### 6.1 Introduction

In response to the “question paradox,” which states that in order to ask what one does not know, one already has to know (Flammer, 1981), this dissertation recasts questions as social epistemological tools of inquiry, rather than as cognitive indicators of individuals’ information needs. A domain comparative approach to inquiry seeks to determine whether one of the ways that knowledge domains are differentiated is by their question formulations, and how these question formulations divulge information about what constitutes an answer and the underlying assumptions of inquiry within the domain. Chapter Five describes the development of a method for identifying the often implicit questions from the knowledge products of inquiry and its application to the abstracts of dissertations about “memory” in three domains: neuroscience, literature, and computer engineering. The current chapter characterizes and compares the content of the domains’ questions, producing a relative picture of what domains ask about in relation to “memory,” and considers what question content conveys about the expected content of the answers that follow the question.

The identification of question content from domain knowledge products is theoretically informed by the logical philosophical approach to questions, namely Brožek’s (2011) erotetic theory. Erotetic theory characterizes questions as a class of expressions that communicate the experience of having an indeterminate cognitive picture of reality and the will to fill it. As applied to domain-level discourse about “memory,” questions express the will to transform an indeterminate situation in the

domain into a determinate one. Abstract-derived question formulations are analyzed based on the analogy between document- and sentence-aboutness: just as logical analysis can determine what a sentence is about, so it can determine what a document, as a sequence or aggregation of sentences (Furner, 2012), is about. The identification of question formulations from the dissertation abstracts was conducted following a nominalist approach to document “aboutness” or subject, rather than a realist approach, defined as considering document aboutness not as an objective property of the work, but as a relation between sets of works, subjects, agents, and dates (Furner, 2012). Accordingly, question content is determined not as an objective property of each individual abstract, but as relative to the other abstracts in the same domain, as well as to the other domains.

This chapter responds to the research questions about question content: (2a) what are the contents of domains’ question formulations on the topic of “memory,” (2b) how do they compare, and (4a) what information do the comparisons convey about the answers that follow? The content of questions and answers about “memory” in neuroscience, literature, and computer engineering are analyzed in order to determine the question content and what the question content conveys about criteria for an answer.

## **6.2 Method for classifying question content**

How do domains compare in terms of the questions they ask about “memory,” which express the indeterminate situations relative to “memory” in each domain? Derr (1984) defines questions as linguistic entities used to make epistemic determinations about objects in the world, having two parts: *subject* and *query*. A question’s subject is a term or terms that refers to an object in the world about which some type of

determination is being sought, while the query is an expression that identifies the particular determination to be made regarding the subject of the question. The subject is that entity which has an uncertain epistemic status; the query is the particular determination that will resolve the uncertain epistemic status. In the sentence, “Who is the president of the United States?” the subject of the question is “the president of the United States, and the query is “Who is he/she?” “The president of the United States” is the object in the world about which a determination is being made; the determination being sought is the identification of his or her identity. Together, the query-subject pairing constitutes the content of the question being posed, describing the epistemic indeterminacy, or indeterminate situation, that the domain seeks to resolve through inquiry. The query-subject pairings demonstrate how questions are formulated to express the indeterminate situation, which is a known unknown in the sense that the manner in which the situation is indeterminate is being expressed.

The method for identifying question content, following Derr’s (1984) conception of question structure and taking as its primary source of data the questions identified in Chapter Five, has two steps: (1) identifying the question’s subject(s) and (2) identifying the query or queries that are being posed about the subject(s).

**6.2.1 Identifying subjects.** Analysis of question *subjects* reveals the kinds of objects – entities or phenomena – that are available to populate domains’ question formulations about “memory” as a topic of domain research. The question formulations identified in Chapter Five are the primary data from which question content is determined, in the context of an in-depth familiarity with the abstracts in their entirety and other secondary data sources including a sample of full-text dissertations, interviews with

thirteen of the dissertation authors, and introductory subject literature. The questions were subjected to open and iterative coding for the *subjects*, the aspects and types of “memory,” its features, or relations, about which some types of determinations are being sought. The questions that guided coding of question subject were, “What is this dissertation about, in regards to memory? What is the memory-related entity or phenomenon in the world about which some type of determination is being made?” Codes were inductively generated according to the principle of constant comparison (Fram, 2013) on a domain-by-domain basis until stability was achieved within each domain and across domains.

**6.2.2 Identifying queries.** Analysis of question *queries* reveals the existential aspects of the “memory”-related subjects that are of interest in the three domains.

Dillon’s (1984) classification scheme for classifying scholarly research questions was adapted to identify the types of queries that are posed by dissertations about “memory”-related subjects (*M*) and other related phenomena (*P*, *Q*, etc.) (Table 25).

Category of query	Knowledge in answer
<i>Zero order</i>	<i>None</i>
0. Rhetorical	No knowledge or no answer
<i>First order: Properties</i>	<i>Individual attributes of M</i>
1. Existence/affirmation-negation	Whether <i>M</i> exists
2. Instance/identification	Whether this is a/the instance of <i>M</i>
3. Substance/definition	What <i>M</i> is
4. Character/description	What <i>M</i> has
5. Function/application	What <i>M</i> does
6. Rationale/explication	Why or how <i>M</i> has a certain attribute.
<i>Second order: Comparisons</i>	<i>Comparative attributes of M and P</i>
7. Concomitance	Whether <i>M</i> goes with <i>P</i>
8. Equivalence	Whether <i>M</i> is like <i>P</i> , and wherein
9. Difference	Wherein <i>M</i> and <i>P</i> differ
<i>Third order: Contingencies</i>	<i>Contingent attributes of M and P</i>
10. Relation	Whether <i>M</i> relates to <i>P</i>
11. Correlation	Whether <i>M</i> and <i>P</i> covary
12. Conditionality	Whether or how if <i>M</i> then <i>P</i> , or if <i>P</i> then <i>M</i>
13. Bioconditionality (causality)	Whether or how if <i>M</i> then <i>P</i> and if <i>P</i> then <i>M</i>
<i>Extra order: Other</i>	<i>Other attributes or ways of knowing M</i>
14. Deliberation	Whether to do and think about <i>M</i>
15. Acquaintance	To know <i>M</i>

16. Unclear	Not known
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**Table 25. Classification scheme for question queries (Modified version of Table 1 in Dillon, 1984)**

Given the use of Derr's (1984) conception of the question as comprising subject and query, what Dillon (1984) originally labels as categories of "questions" are here renamed as "queries," defined as the type of determination being made about  $M$ , the memory-related subject. First-order queries produce knowledge about the properties or individual attributes of "memory." The six first-order categories have a double-label, with the first label indicating the existential aspect of "memory" in question and the second describing the aspect in cognitive terms. The categories are arranged according to the order in which the questions arise, suggesting that knowledge about a phenomenon is built sequentially and incrementally: from affirmation of its existence, to identification of its instantiations, to definition of its substance, and so on. Second- and third-order queries describe comparative and contingent relations between "memory" and other phenomena,  $P$  and  $Q$  (and  $R$ , etc.). The three orders thus describe queries producing propositional knowledge about "memory" along a spectrum, from the fundamental aspect of the existence of "memory" to the ultimate knowledge of its cause. Third order queries of contingency that seek knowledge of relations between  $P$  and  $Q$  do not arise before second order queries that produce knowledge of the comparative attributes of  $P$  and  $Q$ ; second order queries do not arise before first order queries that produce knowledge of the properties of  $P$  itself.

Two additional orders include queries that exist outside of this sequential order. The zero order of rhetorical queries includes queries that preclude inquiry or an answer, such as tautological queries, loaded queries, and contradictory queries. Accommodating

other ways of knowing “memory,” the extra order includes queries of deliberation, as well as a new category emerging from the current analysis, queries of acquaintance.

**6.2.3 Answer content.** Derr’s (1984) classification is a conceptual representation of the correspondence relation between question and answer, in the sense of Hookway’s (2008) proposition that knowledge sentences have indirect question correlates. If the knowledge in the answer is “whether this is a/the instance” of the phenomenon,  $M$ , then the question must pose a query of (2) instance/identification. Conversely, if the question poses a query of (13) biconditionality, then it expresses the requirement that the answer determines “whether or how if “ $M$  then  $P$  and if  $P$  then  $Q$ ” – whether there is a causal relationship between the phenomena. The query-subject pairings are thus categorizations of the domains’ indeterminate situations regarding “memory” that convey the manner of determination that the answer must provide. The answer must provide the known unknown, that which will transform the indeterminate situation into a determinate one. Question and knowledge are complementary sides of the same coin, and the content of the question determines the content of the answer. Queries of (4) character/description produce knowledge of what  $M$  has, queries of (5) function/application produce knowledge of what  $M$  does, and so on. Question content declares the requirements for answer content by virtue of defining the *subject* of inquiry and the type of *query* determination that is being made about the subject.

The domains of neuroscience, literature, and computer engineering are here described in terms of the query-subject pairings emerging from analysis of their questions about “memory,” as identified from the abstracts of 97 dissertations. The analytic focus is on what domains’ question content tells us about what they ask about “memory.”

Question subjects, the memory-related things in the world that the inquiry is about, are identified through inductive coding of the questions. The classification scheme in Table 1 is subsequently utilized to classify the queries, the particular determinations being sought about the memory-related subjects. In some cases, the identification of queries in relation to subjects caused reconsideration and recoding of earlier coded subjects, which resulted in a more consistent set of codes within and across domains. Queries and subjects will be discussed in a paired manner: as some type or types of queries posed about certain memory-related subjects, labeled *query – subject*, together comprising the category of question content. Each question content category is also discussed in terms of what it conveys about the content of the answers that should follow.

### **6.3 Neuroscience**

The questions posed by neuroscience dissertations can be categorized into query-subject pairings in two broad groupings: those of the first order that ask about the properties of memory, and those of the third order that ask about the contingent relations of memory and other phenomena. The subjects identify the memory-related objects or phenomena of uncertain epistemic status, while the queries identify the particular epistemic determination being sought about the subject. Together, they describe the indeterminate situations that constitute the content of neuroscientific questions about memory in a manner that expresses the requirements for an answer.

**6.3.1 Results.** The neuroscientific questions about memory can be characterized by seven query-subject pairings, with the number of question formulations occupying each category indicated in the last column (Table 26).

Query	Subject	No.
<i>First order: Properties</i>		
3. Substance/definition	Neural correlates of memory	3
4. Character/description	Role of <i>X</i> in memory	14
	Neural mechanisms of memory	15
6. Rationale/explication	Memory models or instruments	4
<i>Third order: Contingencies</i>		
12. Conditionality	<i>Y</i> and memory	11
13. Biconditionality	<i>Z</i> and memory	9
	Memory and <i>A</i>	1

**Table 26. Neuroscience: Question content**

The query-subject pairings of the first order describe the content of neuroscience questions about the properties of memory. Three of the dissertations, whose questions are listed in Table 27, pose queries of (3) *substance/definition* about the *neural correlates of memory*, specifically about associative memory (N3), conceptual memory (N5), and successful cognitive aging as defined by working memory performance (N30).

ID	Question
N3	What are the electrophysiological and neural correlates of associative memory?
N5	What is the neural basis of conceptual memory networks in healthy adults and in patients with memory impairments resulting from neurodegenerative disease??
N30	What is the neural signature of “successful” cognitive aging (SCA), as defined by working memory performance?

**Table 27. Neuroscience: Queries of substance/definition about the neural correlates of memory**

Queries of (3) *substance/definition* define the neurological signature of different memory types by directing inquiry towards the definition of the pattern of neurological activity, as indicated by electrical activity or increased blood flow in certain areas of the brain, during the performance of a task that calls upon the type of memory under study. This is the most fundamental work of the neuroscience of memory, engaging subjects in memory tasks in order to identify the pattern of neural activity that defines that type of memory at the neurological level. To be able to locate the patterns of neural activity that represent the memory type, process, or phenomena under investigation is to be able to declare that it exists, in neuroscientific terms. Answers to (3) *substance/definition – neural correlates*

*of memory* questions involve identification of the levels and patterns of neural activity corresponding to the memory-related subject, and the brain region(s) or structure(s) in which the activity appears. The identification of the neural activity's locale provides a context for interpreting the memory type, process, or phenomenon according to what is already known about the various regions and structures of the brain and their role in memory. The queries of (3) *substance/definition* about the *neural correlates of memory* demand that the answers define the patterns of neural activity that correspond to the type of memory or memory phenomenon whose epistemic status is in question.

Beyond the initial identification of *neural correlates of memory*, fourteen dissertations formulate their questions as queries of (4) *character/description* queries about the *role of X in memory* questions, where *X* is subcategorized as being at the *anatomical* or *neuronal* level (Table 28).

<i>Anatomical level (5)</i>	
N9	(1) Whether humans recruit the hippocampus and orbitofrontal cortex to successfully retrieve well-learned overlapping spatial routes; (2) Whether the hippocampus, orbitofrontal cortex, and striatum interact cooperatively to support flexible navigation of overlapping routes; (3) Whether the hippocampus and caudate contribute to forming context-dependent memories
N15	What is the role of the gustatory cortex in learning?
N31	What is the role of the hippocampus and medial entorhinal cortex in time and distance coding?
N38	What are the functional processes of the medial temporal lobes (MTL) and the striatum (the input nucleus of the basal ganglia) during associative learning and memory?
N50	What is the role of hippocampal brain rhythms and neural spikes in episodic memory processes?
<i>Neuronal level (8)</i>	
N6	What is the role of the atypical Protein Kinase C zeta orthologue, PKC Apl III, in synaptic plasticity and long term memory in <i>Aplysia californica</i> ?
N17	What is the role of Homer1c in hippocampal function?
N21	What is the role of histone lysine methylation mechanisms in regulating gene activation and suppression in the medial temporal lobe during memory consolidation?
N28	What is the role of dysbindin in hippocampal-dependent learning and memory?
N36	(1) How are ERK- and mTOR-dependent proteins temporally expressed following acquisition of delay fear conditioning? (2) Whether ERK and mTOR signaling are required for long-term memory formation using selective inhibitors in the amygdala; (3) Whether ERK and mTOR inhibition in the amygdala affects protein expression in other brain regions that receive amygdala inputs
N45	What is the role of BDNF Va166Met in aberrant fear learning in both humans and animal models, particularly during the developmental transition into and out of adolescence, when anxiety and affective disorders are most prevalent in human populations?
N47	What is the contribution of Cdh1 to learning and memory at both developmental and adult stages?

N49	What is the role of small RNAs in memory-related synaptic plasticity in <i>Aplysia</i> ?
N51	How can psychostimulants modulate memory processes and create addiction-like memories in mice?

**Table 28. Neuroscience: Queries of character/description about the role of X in memory**

Following the definition of the neural correlates of different types of memory, (4) *character/description – role of X in memory* questions seek to describe the neural components of various types of memory. At the *anatomical* level, the queries ask about and produce knowledge of the specific brain structures that play a significant role in some type of memory: the role of the hippocampus in spatial memory (N9) and episodic memory (N50); the role of the gustatory cortex in learning and memory (N15); the role of the hippocampus and medial entorhinal cortex in time and distance coding (N31); and the role of the medial temporal lobe and striatum during associative learning and memory (N38). The answers to these queries describe the roles that the anatomical structures play in relation to memory – the ways in which they interact with other structures and how they function as a part of larger memory and learning systems, for example, “that both the MTL and striatum participate in the learning of arbitrary associations but also dynamically interact during learning” (N38).

At the *neuronal* level, eight questions consider the role of specific protein kinases in relation to the memory processes that they enable: PKC Apl III in synaptic plasticity and long-term memory (N6); Homer1c in hippocampal function (N17); histone methylation in the medial temporal lobe during long-term memory formation (N21); dysbindin in hippocampal-dependent learning and memory (N28); ERK and mTOR-dependent proteins during memory consolidation (N36); Cdh1 in fear learning and memory (N47); BDNF Va188Met in aberrant fear learning (N45); and 5-HT3 receptors in extinction of learned fear such as that resulting from traumatic events (N44). Apart

from the study of specific proteins but also at the cellular level, one question is about the role of small RNAs in synaptic plasticity (N49). The *(4) character/description – role of X in memory* questions require answers that describe the role of proteins and RNA in producing memory, such as “that PKC Apl III is cleaved into PKM Apl III during memory formation, and the requirements for cleavage are the same as the requirements for the plasticity” (N6).

Fifteen neuroscience dissertations formulate their questions as queries of *(4) character/description* about the *neural mechanisms of memory* (Table 29).

N8	Whether long-term memory is distorted by information erroneously retrieved from episodic memory.
N19	(1a) Whether item inhibition or binding is involved in proactive control; (1b) Whether familiarity inhibition or episodic inhibition is involved in reactive control; (2) How do proactive control and reactive control mechanisms work together to resolve proactive interference? (3) Do these mechanisms play a role in the relationship between PI resolution and WM?
N23	(1a) What are the neural processes involved in selecting relevant spatial locations from working memory? (1b) What is the subsequent effect on recognition? (2a) What is the timing at which relevant and no longer relevant spatial locations were separately represented? (2b) Whether the post-updating neural activity was modulated by different amounts of relevant and no longer relevant information
N24	How does the acquisition of an associative memory for a stimulus both depend upon and affects gamma oscillations?
N25	How do place cells resolve conflicting neuronal input signals?
N29	Whether there are variations, in contexts, people, and use in semantic memory retrieval.
N34	(1) What are the neural mechanisms of attention? (2) How can it influence our motor responses, memory, and behavior without perceptual awareness?
N35	How do episodic memories accumulate across longer time scales and multiple presentations?
N37	What are the underlying neurocognitive interactions between fluency and familiarity memory?
N39	How do spatial and working memory reorganize due to aging in the human brain?
N40	Whether Bekkers and Stevens alternate hypothesis, that information could be stored by the bound-but-blocked (non-conducting) state of the NMDA receptors, is confirmed with inclusion of factors required for dendritic spikes during signal read-out
N41	How are our brains able to flexibly hold or the relevant rules of working memory in mind?
N44	How is new learning associated with the extinction of fear related memories mediated via actions involving 5-HT <sub>3</sub> receptors and possible changes in GABAergic neurotransmission?
N52	Whether systems consolidation is temporally based or not
N56	(1) What is the function of reward and flexible learning systems in value-guided decision making? (2) How does ongoing reward learning modulate memory formation in the hippocampus?

**Table 29. Neuroscience: Queries of character/description about the neural mechanisms of memory**

These questions seek to describe the neural mechanisms that constitute memory as a process and phenomenon. They focus inquiry on the neural signals or “neural circuitry”

(N42) of three main processes: encoding the memory (further broken down into stages of acquisition and consolidation), storage (retaining and maintaining the information in the brain over time), and retrieval (reactivating a stored memory for use when needed). The neural processes associated with types of memory in this sample of questions include: the acquisition of associative memories (N24); punishment-motivated encoding of declarative memory (N42); and the reward learning-modulated encoding of episodic memories in the hippocampus (N56); the consolidation of retrieved memories (N8); accumulation of episodic memories (N35); and the updating and storage of spatial information (N23). Also of interest are the neural mechanisms of: memory-processing fluency (N37), re-organization of spatial and verbal working memory due to age (N39), information processing related to working memory (N40; N41), and proactive interference related to working memory (N19). By asking queries of (4) *character/description* about the *neural mechanisms of memory*, these questions demand answers that describe the way in which memory functions in the biological substrate.

Four dissertations formulate their questions as queries of (6) *rationale/explication* about *memory models or instruments* (Table 30).

N22	What conventional and ethologically relevant forms of reinforcement are most effective in the study of fear conditioning in rats?
N32	What adaptive training can be developed for patients with low visual working memory (VWM) capacity to improve cognitive abilities and healthy individuals who seek to enhance their intellectual performance?
N46	What alternate paragraph (Morris Revision-IV) for the WMS-IV Older Adult Battery Logical Memory Subtest can be developed for the continued assessment of older adults?
N53	What computational cognitive neuroscience model of episodic memory based on the mammalian brain can be developed?

**Table 30. Neuroscience: Queries of rationale/explication about memory models or instruments**

These questions differ from the rest of the first-order neuroscientific questions, as they do not ask directly about the phenomenon of memory, but about the instruments of study: a

novel paradigm for studying fear conditioning in rats (N22), a measurement tool for assessing older adults' memory (N46), a training for patients with low visual working memory capacity (N32), and a computational model of memory for the study of mammalian episodic memory (N53). The queries of (6) *rationale/explication* convey an expectation that the answer explain why the proposed tools for studying memory are designed as they are, and how they fill the purpose for which they are designed.

Grouped into categories according to subject and query, it is apparent that first-order questions in neuroscience mostly take the linguistic form of what- and how-questions. The what- questions seek to identify, define, or describe memory as a neuroscientific phenomenon. The how- questions seek to discover how memory functions neurologically. Both question types reveal the current state of knowledge by defining the indeterminate situation in the form of a query (unknown) posed about a subject (known). To ask, "What is the role of the gustatory cortex in learning?" (N15) is to indicate that it is known that the gustatory cortex has a role in learning (subject = *role of X in memory*), but the precise role is unknown (query = *character/description*). When the research question asks, "How do episodic memories accumulate across longer time scales and multiple presentations?" (N35), one may infer that it is known that episodic memories do accumulate across longer time scales and multiple presentations (subject = *neural mechanisms of memory*), but that the exact workings of the mechanisms by which they do are unknown (query = *character/description*). In this manner, the question content expresses the known unknown that is in the indeterminate situation and conveys an expectation for the answer to resolve the indeterminacy.

The neuroscience abstracts also pose questions that produce third-order knowledge of the contingent relations between memory and other phenomena. Eleven dissertations pose queries of (12) *conditionality* about *Y and memory*, where *Y* is defined as: *diseases and disorders, traumatic brain injury, age, and individual differences* (Table 31).

<i>Diseases and disorders (5)</i>	
N10	Whether memory deficits reported by and neurobiological correlates of encoding and performance of ill Gulf War Veterans differ from those of well GWV in a nationally representative sample
N16	Whether working memory performance differs between children diagnosed with ADHD and children diagnosed with ADHD with comorbid anxiety or depression
N43	What are the patterns of verbal and visual learning and memory, as well as cognitive predictors of functional abilities in MCI, for 71 individuals with consensus-diagnosed MCI enrolled in the Measuring Independent Living in the Elderly Study (MILES) as compared to controls?
N48	Whether everyday functioning differs between between 33 PD patients and 26 demographically comparable adults
N54	Whether healthy patients demonstrate an “inverted-U” response to the self-ordered WM task that is absent in patients with schizophrenia.
<i>Traumatic brain injury (3)</i>	
N2	Whether verbal memory will be more severely impacted than nonverbal memory in a bilingual pediatric TBI population as compared to a monolingual pediatric TBI population
N11	(1) Whether participants with moderate to severe traumatic brain injury (MOD/S TBI) would quantitatively and qualitatively differ from participants with no brain damage (NBD) in phonemic and semantic verbal fluency; (2) Whether the potential differences may be attributed to working memory (WM) and information processing speed
N18	Whether the neural substrates of working memory and object location memory differ between healthy males and males with traumatic brain injury
<i>Age (2)</i>	
N14	Whether there are age-related changes to the neural networks recruited during emotional and specific autobiographical memory retrieval when cued by music
N26	Whether there are age differences in the retrieval and definition of events from memory
<i>Individual differences (1)</i>	
N33	Whether associative inference is possible with and without awareness

**Table 31. Neuroscience: Queries of conditionality about *Y* and memory**

Queries of (12) *conditionality* ask whether and to what extent the differences between two groups according to the dependent variable, memory, can be attributed to the independent variables of interest. Known as *ex post facto* or causal comparative research, it differs from research posing queries of (11) *correlation* in that two or more groups are being compared rather than two or more variables within one group. Since it lacks random assignment, substituting groups with pre-existing differences in cases when

random assignment is unethical or otherwise not possible, research posing queries of (12) *conditionality* do not achieve true causality as do queries of (13) *biconditionality*, described below. Dissertations posing queries of (12) *conditionality* seek to establish that differences in memory activity or performance are likely caused by *diseases and disorders* such as Mild Cognitive Impairment (N43), Parkinson's Disease (N48), or schizophrenia (N54); *traumatic brain injury* (N2; N11; N18); *age* (N14; N26); or *individual differences* (N33). The question content of these query-subject category communicate an expectation that the answers demonstrate that impaired memory can be conditionally attributed to the *diseases or disorders, age, or individual differences* that differentiate the experimental groups.

Nine questions pose queries of (13) *biconditionality* about *Z and memory*, where *Z* is subcategorized as *cognitive interventions, drugs, stress, and mode of presentation* (Table 32).

<i>Cognitive interventions (4)</i>	
N1	Whether the experimental group receiving a 12-week neuroscience-based, cognitive-skills computer-training program differs from the control group on the cognitive processing of 40 elementary students in grades 2-4 with specific learning disabilities (SLD).
N20	What are the practical utility and mnemonic mechanisms of self-imagination, a novel cognitive strategy designed to capitalize on self-referential processing?
N27	How do emotion regulation goals modulate autobiographical recall at both a behavioral and neural level?
N42	Whether reward and punishment motivation influences human declarative memory encoding and its underlying neural circuitry.
<i>Drugs (3)</i>	
N4	Whether amphetamines affect emotional memory
N7	Whether prenatal alcohol exposure (PAE) leads to impairments in dentate gyrus-dependent learning and memory, which is associated with NMDA receptor-dependent LTP deficits and NMDA receptor subunit composition alterations in the dentate gyrus
N13	Whether chronic treatment with the serotonin 2A antagonist SR 46349B enhances retention and efficiency of rule-guided behavior in mice
<i>Stress (1)</i>	
N12	What is the effect of psychosocial stress on memory updating?

<i>Mode of presentation (1)</i>	
N57	Whether there is a difference in the quantity of episodic memory that is stored when the presentation of linguistic materials is visual (read by the individual) versus auditory (heard by the individual)?

**Table 32. Neuroscience: Queries of biconditionality about Z and memory**

The dissertations in this subset are identifiable by the research design implied in their questions. These questions seek to establish a causal relationship between certain phenomena and the dependent variable of enhanced or improved memory. To establish causality, two or more populations are studied in terms of the dependent-independent variable relationship. While the question may not specify the presence of a control group, queries of (13) *biconditionality* randomly assign participants to experimental and control groups rather than comparing groups with existing differences. The basic question being asked is, do the experimental and control populations demonstrate a statistically significant difference in the effect of the *cognitive intervention, drugs, or mode of presentation* on the dependent variable of memory performance or neural activity?

Overall, the (13) *biconditionality – Z and memory* questions produce knowledge about phenomena that can enhance or impair memory. Four dissertations ask about the enhancing effect of *cognitive interventions*: the effect of a cognitive neuroscience-based computer training on cognitive processing (N1); of self-imagining on cued recall (N20); of emotion regulation goals on autobiographical recall (N27); and of reward and punishment motivation on declarative memory encoding (N42). Three dissertations ask about the enhancing or impairing effects of *drugs*: the effect of amphetamines on humans' emotional memories (N4), of 5HT2A receptor up-regulation on cognitive processes of learning and memory in mice (N13), and of psychostimulants on the memory processes of mice (N51). One query asks about the impairing effect of *stress* on memory updating and consolidation (N12). Another asks about the difference in quantity according to the

*mode of presentation* (N57). By posing queries of *(13) biconditionality*, these questions demand that the answer express that if memory is improved or enhanced, it is due to the intervention; if the intervention is administered, then memory will be enhanced or improved. If so, it can be said that the independent variable differentiating the experimental and control groups has a causal effect on the dependent variable.

One dissertation poses a *(13) biconditionality – memory and A* question, more specifically, about the causal relationship between memory-based strategies for physical rehabilitation and increased physical mobility of Alzheimer’s disease patients (Table 33).

N55	Whether implicit memory and learning strategies, including high-repetition practice, errorless learning (EL), and spaced retrieval (SR) improve objective measures of balance, performance on the Timed Up and Go test (TUG), and self-selected gait speed (ssGS).
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**Table 33. Query of biconditionality about memory and A**

This query of *(13) biconditionality* differs from the others in its interest in memory as the independent variable rather than the dependent: the causal effect of memory on another phenomenon rather than of another phenomenon on memory.

Questions posing queries of *(12) conditionality* or *(13) biconditionality* ask whether or not relationships between memory and other phenomena can be confirmed. In Derr’s (1984) conception of question structure as query and subject, the subject is the known thing in the world about which an epistemic determination is being made; the query is the unknown type of epistemic determination. In these terms, the third-order query-subject pairings indicate that enough is known to suggest a relationship between *Y and memory* (subject); what is unknown is whether or whether a relationship of *(12) conditionality* (query) can be shown. Likewise, enough is known to suggest that the *Z and memory* (subject) are related, but what is unknown is whether the relationship is causal, one of *(13) biconditionality* (query).

**6.3.2 Discussion.** What do the query-subject pairings tell us about question content related to “memory” in the domain of neuroscience? Neuroscientific questions about memory divide into two groups based on Dillon’s (1984) classification scheme of research questions (Table 25): those employing queries of the first order, producing knowledge in their answers about the neural properties of memory, and those employing queries of the third order, producing knowledge of memory’s relations to other phenomena. By considering the query-subject pairings as a whole, a picture begins to emerge of two different areas of neuroscientific research on memory, as manifested in the types of epistemic determinations indicated by the query type, and the memory-related objects or phenomena in the world about which the determinations are being made, the subjects. Together, the query-subject categories describe the different indeterminate situations about “memory” that are found in the neuroscience sample.

The first order query-subject pairings address three of the four issues that Byrne (1997) identifies as central to research on learning and memory. First, what are the different types of memory? Second, where in the brain is memory located? The (3) *substance/definition – neural correlates of memory* questions seek to differentiate the different types of memory by interpreting the patterns of neural activity throughout the various anatomical structures of the brain that correspond to the performance of memory tasks. The (4) *character/description – role of X in memory* and – *neural mechanisms of memory* questions produce fundamental knowledge of the way in which individual structures work together to produce memory and of memory’s processes – how it is perceived, encoded, consolidated, maintained, distorted, retrieved, and extinguished. Finally, (6) *rationale/explication – memory models and instruments* questions mark

neuroscientific inquiry as highly dependent on continually developing technology for “seeing,” measuring, and representing memory. They represent the reflexive dimension of domain inquiry into memory, asking, are our models and instruments accurately measuring and representing memory? As a group, the first order questions seek to establish epistemic certainty about memory as a neuroscientific phenomenon and the manner of its study.

Third order questions produce knowledge of the contingent attributes of memory, more specifically, about the relations of (12) *conditionality* or (13) *biconditionality* between some phenomena and memory. These questions address the fourth central question of memory and learning: how can memory be maintained and improved, and how can it be fixed when it is broken (Byrne, 1997)? Queries of (12) *conditionality* ask whether *diseases and disorders, traumatic brain injury, age, and individual differences* are the likely cause of differences between groups’ neural activity and memory performance. Queries of (13) *biconditionality* produce knowledge of the causal effect of *cognitive interventions, drugs, mode of presentation, and stress* on memory performance and the neural activities of memory.

Only one question is posed in the form of a query of (13) *biconditionality* about *memory and A*, asking whether strategies using the implicit memory system can be applied to the physical rehabilitation of Alzheimer’s patients (N55). The current sample suggests that this single instance of a query-subject pairing where memory is the independent variable is not central to the domain approach to memory. At the domain level, it may represent an emerging or waning area of research, being at the forefront or the tail end of domain knowledge production relative to the query type. Alternately, an

infrequent query-subject pairing may represent a unique stance between domains, as in inter- or multi-disciplinary research. Or it may be a question that is miscategorized as belonging primarily to the neuroscientific domain, perhaps more accurately belonging to the domain of physical therapy, or Alzheimer's research. Finally, it may also indicate an ill-formulated question that simply fails to adhere to domain standards rather than representing a new area of domain interest. Here we are making a distinction between questions that are formulated in reference to one or more existing domains, that attempt to extend, expand, refine, or combine existing domain approaches, as compared to those that are merely ill-formulated in reference to the target domain audience. The current question analysis does not attempt to determine which of these applies to the single instance of this query-subject pairing, but proposes that the identification of the query-subject pairings is the first step in being able to make those judgments.

**6.3.3 Summary.** The analysis shows that the content of neuroscientific questions about memory can be divided into two basic groups of query-subject pairings: (1) those of the first order, posing queries of (3) *substance/definition*, (4) *character/description*, and (6) *rationale/explication* about the properties of memory; and (2) those of the third order, posing queries of (12) *conditionality* and (13) *biconditionality* about the contingent relations between memory and other phenomena. The two broad groupings characterize the known unknown, or the indeterminate epistemic situations, of neuroscientific knowledge of memory, and convey expectations for the answer to resolve the indeterminacies. Neuroscientific inquiry into memory is an endeavor that is simultaneously producing basic knowledge of memory as it occurs in the biological substrate of the brain and knowledge of the ways in which it is affected – impaired,

enhanced, or simply changed – by phenomena such as age, diseases and disorders, traumatic brain injury, cognitive interventions, and others. These two approaches to producing neuroscientific knowledge of memory are reflected in the content of the questions and answers in neuroscientific dissertation abstracts about memory.

## 6.4 Literature

What types of indeterminate situations regarding memory are addressed by the dissertations in the literature domain? The question formulations identified in twenty literature dissertation abstracts are represented by four different query-subject pairings across two orders of knowledge (Table 34).

Query	Subject	Count
<i>First order: Properties</i>		
6. Rationale/explication	Literary uses of memory	10
	Literary construction of memory	6
	Cultural memory of literary figure	1
<i>Extra order: Other</i>		
15. Acquaintance	Nature of memory	3

**Table 34. Literature: Question content**

**6.4.1 Results.** Seventeen of the twenty questions ask queries of (6) *rationale/explication* about memory. *Rationale/explication* queries belong to the first order in the classification scheme that produces knowledge of the properties of memory, in this instance, of why or how literary memory has certain attributes. Of the seventeen questions, ten pose queries of (6) *rationale/explication* about the *literary uses of memory* questions, such as *to challenge historical memory*, *to negotiate trauma*, or for *general use* (Table 35).

<i>General</i>	
L6	How does Andrea Camilleri use a common cultural memory to provide a "security blanket" for his readers and keeping his readers safely anchored?
L13	How, conceived as spaces of memories, do the United States and Mexico become the loci of cultural becoming for France and the United States?
L18	How does the European postcolonial and migrant literature I read claim the history of the Jewish

	Question and Holocaust memory as critical resources for Europe's new migrants and diasporic communities?
<i>To challenge historical memory</i>	
L2	How are the uBumbano using the idiom of heritage, as well as a traditional idiom of kinship that has come to be handed down as a Zulu language for mediating social relations by the uBumbano, in ways that challenge the centrality given to Shaka in narrations of the past?
L5	How has post-war literature created an alternate and competing memory of Fascism's twenty-year rule?
L10	How do postmodernist narratives of memory in Graham Swift's <i>Waterland</i> , Salman Rushdie's <i>Midnight's Children</i> , and Amitav Ghosh's <i>The Shadow Lines</i> retrieve the stories of those who have been lost or forgotten in official history and refigure the temporal and spatial imaginary?
L20	How do writers use highly imaginative crónicas as a means to uphold or challenge official memory and history and to propose "alternative" readings of the nation during Mexico's centenary and bicentenary commemorations of Independence of 1910, 1921, and 2010?
<i>To negotiate trauma</i>	
L1	What are the literary devices that three texts utilize to negotiate the fragmentation that characterizes the traumatic aftermath and signify the necessity of a retrospective gaze towards the atrocious past?
L3	How do these women writers use various aesthetics in portraying the landscape of memories to represent, redefine, and transcend repetition, trauma, and loss, and to renegotiate the reality of the past, present, and future?
L15	How does a woman writer memorialize her own traumatic history, when it happens to be part of a larger History dominated by male narratives (as far as Holocaust and slavery go), or when it is altogether silenced (as is the case for madness and institutionalization)?

**Table 35. Literature: Queries of rationale/explication about the literary uses of memory**

The three dissertations posing *general* questions ask about how memory is used by literary texts: how cultural memory functions as a “security blanket,” providing safe anchor for readers of a bestselling author’s detective novels even as they participate in a “(post)modern shift of horizons” (L6), or how European and postcolonial migrant literature uses the memory of the Holocaust to “reveal the insufficiency of liberal strategies for the management of difference, and signal the danger of current versions of racist thought” (L18). In these questions, memory is wielded by literary texts in order to accomplish some desired effect or result, such as when the act of remembering “critically disrupts” the “strategic forgetting...and simultaneous repurposing” (L18) of memories of traumas such as the Holocaust and Fascism. These queries of (6) *rationale/explication* communicate an expectation that the answers provide explanations

of why or how the literary uses of memory accomplish the desired effect or result towards which memory is applied.

The four questions about literary uses of memory to *challenge historical memory* resist the notion that history is a factual and neutral representation of past events, exploring the ways in which memory is intertwined with identity, agency, and issues of truth and power. The research produced by these questions challenges the official record of historical events, with varying degrees of creative energy. Literary texts may “uphold or challenge official memory and history” (L20), challenge the dominance of certain discursive views of history over others (L2), retrieve lost or forgotten stories (L10), or even create “an alternate and competing memory” to “the dogmatic truths on the public memory of the war” (L5). Queries of (6) *rationale/explication* convey the criteria that answers explain why or how literary challenges to historical memory have the attributes of that they do: to contest dogmatic truths, retrieve forgotten ones, and even create new truths, through the subversive use of traditional genres such as idioms (L2) and crónicas (L20), or the production of counter-narratives to the dominant discourse (L5; L10).

Three dissertations ask about the literary uses of memory *to negotiate trauma*. These questions ask how “the fragmentation that characterizes the traumatic aftermath” (L1) and the domination and silencing of women’s traumatic histories by male narratives (L15) are negotiated and resisted by literary texts. Whether manifesting as trauma-induced amnesia, the repression of traumatic memories, or cultural or generational silence about collective trauma, the relationship between trauma and memory is fraught with choices of whether and how to remember one’s trauma, as we are reminded that “the issue of forgetting as an eternal return to remembering” (L3). There is potential for

continuing harm, re-victimization, and passing on of effects of trauma to the next generation, but also for reclaiming agency, as when women writers “renegotiate socially, construct cultural identities, conceptualize, reposition or discover their silent selves” (L3), or when memory is placed in an intersubjective context, “which goes beyond the simple individual plight to comprehend the need to be an ethically responsible agent of remembrance in the present” (L1). By posing queries of (6) *rationale/explication*, these questions solicit answers that explain how and why authors negotiate the traumatic aftermath as they do.

Six dissertations formulate questions that pose queries of (6) *rationale/explication* about the *literary construction of memory* (Table 36).

ID	Question
L4	What is the relationship between the violence of the events of the "liberation struggle" in Zimbabwe and South Africa and the memory of them in selected exemplary fiction and film texts?
L8	What/where is the nexus of aesthetic theory, historical memory, and emergent "community" that is inherently heterogeneous and does not revolve around an exemplary subject?
L11	How are memory and history embedded in images of the built environment? How, in turn, does this spatialization of the past contribute to a criticism of traditional linear narration?
L12	How does intergenerational, trans-temporal trauma become re-narrativized and re-envisioned over time in four symbolic sites of slavery (five countries) – Africa (Ghana and Mozambique), the Caribbean (Cuba), Brazil, and the United States) – with the goal of exposing differences and emphasizing ruptures?
L14	What are the technics of temporal memory in twentieth-century modernist and post-modernist literature and film?
L19	What are the different strategies - both rhetorical and political - "Franco's children" used at three key historical moments: 1) the transition to democracy in the early 1980s; 2) the mid and later 1990s; and 3) the period following the Law of Historical Memory [October 31, 2007] by "Franco's children" in <i>El Sur</i> , <i>El florido pensil</i> , <i>Habíamos ganado la guerra</i> , and <i>La gloria de los niños</i> ?

**Table 36. Literature: Queries of rationale/explication about the literary construction of memory**

The questions posed by these dissertations ask how the literary portrayal of memories, through dissident narratives (L4), decentering of the exemplary subject (L8), images of the built environment (L11), intertextuality (L12), and rhetorical strategies (L19), serve as the lens through which meaning is ascribed to the content of the memories, whether personal or cultural. These questions are at the core of the literary inquiry into memory –

not as a representation of past experiences, but as creative act of construction, often reshaping, redefining, or renegotiating memory as an explicit act of resistance, or as a byproduct of the creative act. The queries of (6) *rationale/explication* seek answers about why or how memory is constructed as it is in literary texts, demonstrating that the way in which memory is written about is itself revealing of both the nature of memory and the nature of writing.

One question formulation poses a query of (6) *rationale/explication* about the *cultural memory of a literary figure*, seeking to understand what happens to the cultural memory of a French writer and theologian between the nineteenth century and the first decades of the twentieth century, during which he goes from being one of the most esteemed writers in French history to a largely disregarded figure, as judged by critical interest in his works (Table 37).

L9	How do references to the name of Fénelon in nineteenth-century literature through to the writings of Proust reflect and affect the changing French imagination of him whose posterity became a standard for the remembrance of <i>grands hommes</i> and <i>pantheonization</i> in the nineteenth century?
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**Table 37. Literature: Queries of *rationale/explication* about the cultural memory of a literary figure**

Underlying this investigation is a pursuit to understand what kind of a process is memory, as the changing status of Fénelon in the cultural memory cannot be explained by an understanding of memory as reconstructive in nature. The query of (6) *rationale/explication* calls for an answer that explains how the situation of Fénelon suggests that memory is referential in nature, as explained by the fact that

Fénelon's name appears hundreds of times in the literature of the long nineteenth century, and the context surrounding his name offers a view of the posterity of Fénelon which contradicts what is available through an investigation of

biographies and academic studies of his theological and literary work alone.”

(L9)

The premise that the cultural memory of Fénelon is reflected in references to Fénelon's name in the broader literature and not only in direct biographical or critical treatments of his body of work serves as evidence that the nature of cultural memory is referential, not only reconstructive.

The literature sample shows that the domain asks mostly how- questions, and sometimes what- questions, about memory. The how- questions ask how literary texts or authors of literary texts accomplish certain things related to memory through literary technical means, such as when one dissertation asks, “How do writers use highly imaginative crónicas as a means to uphold or challenge official memory?” (L20). The what- questions solicit definition or description of the literary devices utilized, as when asking, “What are the different strategies - both rhetorical and political – ‘Franco's children’ used at three key historical moments” (L19) in select literary texts? What is known is that the interest is in the *literary uses of memory*, *literary construction of memory*, and *cultural memory of a literary figure* (subject); what is unknown is its (6) *rationale/explication* (query). It is known that literary texts construct memory and negotiate trauma, but the unknown is how and why it does so.

Distinct from the rest of the query-subject pairings, three dissertations pose extra-order queries of (15) *acquaintance*. Rather than soliciting an answer, queries of acquaintance are an invitation to know through direct experience. The questions characterized by this query-subject pairing are posed by works of creative fiction, in the

form of two novels and a short story collection. These dissertations ask about the *nature of memory* (Table 38).

L7	What is the nature of memory (individual vs. collective)? How do we as humans and creative artist continue to grapple with, and attempt to reorder, our memories?
L16	What is the nature of memory (individual vs. collective)? How does patriarchal culture ignore and ultimate punish women's anger and desire?
L17	What is the importance of myth, memory, tradition, and place within a Southern context?

**Table 38. Literature: Queries of acquaintance about the nature of memory**

The two novels invite readers into the direct experience of the nature of memory, whether collective or individual, through immersion into the protagonists' perspectives: that of a 32-year old protagonist on a quest to reignite the romantic relationship he shared with his fourth-grade teacher (L7) or of a amnesic woman struggling to regain her identity and sense of belonging after a violent attack (L16). The third, a collection of short stories, invites the reader to become acquainted with the nature of memory in the Southern context, in which "place" is more than just the geographical setting of the stories, but is some intangible combination of the natural and man-made landscapes, objects, people and relationships, the passing of time and events, even encompassing myths and folktales. Characters' memories, their recollections and retellings of these various manifestations of place, form the foundation from which their identities as rural Southerners spring.

Queries of (15) *acquaintance* occupy the extra order in the classification scheme, indicating that the knowledge produced in reply to these types of queries is outside of the sequential and incremental scheme of propositional knowledge produced by queries of the first three orders. These questions communicate the expectation that the answers are composed of direct experience the *nature of memory* through our own senses, of becoming acquainted directly *with* memory, rather than simply knowing *about* it.

Queries of (15) *acquaintance* display the logic of what- questions about the subject. The what- questions seek to produce first-order knowledge of the properties of memory, specifically, of the nature of memory: its essence, its innate and inherent properties. In L7, the question of “what is the nature of memory?” is followed by a how- question that directs the inquiry towards a consideration of the malleable nature of memory: “How do we as humans and creative artists continue to grapple with, and attempt to reorder, our memories?” L16 also asks “what is the nature of memory?” with the subsequent question directing inquiry towards a consideration of the nature of women’s memories as collective, as a product of patriarchal cultural forces of oppression. In terms of the question’s indication of the known unknown, what is known in theme-driven literary inquiries is the focus of inquiry: the nature of memory (subject). What is unknown is (15) *acquaintance* (query) with the subject, or the direct experience of it. The three creative writing dissertations take the form of literary works of fiction that pose a broad question about *the nature of memory* and invite the reader to formulate an answer through direct acquaintance with memory in the texts.

**6.4.2 Discussion.** What does the overall pattern of query-subject pairings tell us about the nature of question content related to “memory” in the domain of literature? The literary inquiries into memory in our sample can be divided into two types of question content according to query type: queries of (6) *rationale/explication* and queries of (15) *acquaintance*. First-order queries of (6) *rationale/explication* ask about *literary uses of memory, literary construction of memory, and the cultural memory of a literary figure* in selected literary texts. In comparison to neuroscientific first-order questions that seek to identify, define, and characterize the neurobiological substance and character of

“memory,” literature is interested in its function, in applying it to accomplish some actions, and how literary texts utilize memory to enact those functions. By challenging the official historical discourse, literary memory questions the past, recreates the present, and opens up the potential for the future. It negotiates the aftermath of personal or collective trauma, finding ways to make sense of fragmented reality, to transform the traumatic experience by becoming witnesses against future atrocities. The queries of (6) *rationale/explication* produce knowledge of why and how the literary phenomenon of memory is constructed as it is, whether through the use of genre, narrative and structural experimentation, rhetorical strategies, or aesthetic perspectives. Overall, the seventeen queries of (6) *rationale/explication* present the critical dimension of literary inquiry into memory, the analysis and interpretation of literary texts for their use of memory.

A small but significant set of creative writing dissertations pose extra-order queries of (15) *acquaintance* about the *nature of memory*, dividing the domain into distinct sub-domains of content. These dissertations invite direct experience, in this case, unmediated engagement with literary works of fiction as contrasted to the mediated engagement with texts encountered in literary theory and criticism. They form an important subset of queries distinct from all the others in the three domains, as they uniquely frame the production of knowledge. The distinction, as articulated by Bertrand Russell (1910) is between knowledge that is indirect, mediated, and inferential (“knowledge by description”), as is produced by queries ranging from (1) existence/affirmation-negation to (13) *biconditionality* in Dillon’s (1984) scheme, and knowledge that is direct, unmediated, and non-inferential (“knowledge by acquaintance”). To know something by acquaintance, says Russell (1914), is to have a direct cognitive

relation to the object or phenomenon, to be directly aware of the phenomenon itself. The ontological commitment of queries of (15) *acquaintance* is to this subject-object relationship (Russell, 1914), or in memory-related terms, the relationship between agents and memory itself, rather than theories of or arguments about memory. Russell describes acquaintance as the converse of the relation of subject and object that constitutes presentation: an object is “presented” to a subject, and the subject becomes “acquainted” with the object.

The questions posed by the creative writing dissertations present memory to the reader, and the reader becomes directly acquainted with memory by reading the texts. Russell (1914) would classify both as types of propositional knowledge, but would distinguish knowledge-by-description as declarative knowledge of propositional truth, while knowledge-by-*acquaintance* is unmediated awareness of the propositional truth through firsthand sense data. This is the type of knowledge that is conveyed by works of art; they *present* the object or phenomenon (“memory”) to the reader, bringing the object itself before the mind and inviting them to “know” through acquaintance, directly through the senses, not inferentially through propositions.

**6.4.3 Summary.** The content of literary questions about memory can be divided into two categories of indeterminate situations: queries of (6) *rationale/explication* about the *literary uses of memory*, *literary construction of memory*, and *cultural memory of a literary figure*; and queries of (15) *acquaintance* about the *nature of memory*. Queries of (6) *rationale/explication* convey the expectation that the answer explain how the literary texts disrupt forgetting, retrieve forgotten stories, renegotiate reality, resist or subvert dominant discourses, create alternate histories, and expand the borders of the imaginary.

In contrast, queries of *acquaintance*, as utilized by the three creative writing dissertations, invites direct experience, rather than literary analysis, of the nature of memory as it is expressed in works of creative fiction. The two query-subject groupings present the boundary of literary knowledge in terms of these two basic indeterminate situations: how or why literary texts apply memory to accomplish some desired actions (queries of rationale/explication) and direct knowledge of the nature of memory (queries of acquaintance).

## 6.5 Computer engineering

What are the subjects and queries that characterize question content related to “memory” in the domain of computer engineering? Nineteen dissertations in this sample formulate questions by posing queries of (6) *rationale/explication* about *memory optimization*. One dissertation, mistakenly labeled as belonging to the computer engineering domain, poses a query of (11) *correlation* about *memory and B* (Table 39).

Query	Subject	No.
<i>First order: Properties</i>		
6. Rationale/explication	Memory optimization	19
<i>Third order: Contingencies</i>		
11. Correlation	Memory and B	1

**Table 39. Computer engineering: Question content**

**6.5.1 Results.** Queries of (6) *rationale/explication* produce first order knowledge about the properties of memory, specifically, about why and how the *memory optimizations* being proposed by the dissertations have the attributes that they do. The nineteen computer engineering dissertations can be subdivided according to whether the problem of *memory optimization* is approached at the level of entire *memory systems*, individual *memory technologies*, *memory models*, or *memory circuits*.

The highest level at which optimization can occur is at the *memory systems* level

(Table 40).

ID	Question
CE4	What is the behavior of the buffer-on-board memory system? What is the optimal use of the resources involved?
CE12	How should several flavors of memory and logic implementation be realized, considering the versatility and scope of nanoscale devices, in particular the memristor, when employed in different nanoelectronic and hybrid CMOS/Nano circuits?
CE15	What hybrid DRAM-PCM memory systems for servers provide robust and consistent memory performance without sacrificing energy?
CE18	What are the key bottlenecks to efficiency in the memory system?

**Table 40. Computer engineering: Queries of rationale/explication about memory optimization – memory systems**

These questions ask how memory systems are designed or should be designed in order to overcome “key bottlenecks to efficiency” (CE18) or to provide “the optimal use of the resources involved” (CE4). The responses are of several types: analysis of every major element of the main memory system and proposal of a novel system with innovative features to overcome the bottlenecks to efficiency (CE18); the proposal of hybrid main memory systems, which combine two different main memory technologies whose advantages and disadvantages in terms of speed, capacity, volatility, ease of use, cost of production, and power consumption complement each other, allowing for the computer to call upon one or the other, depending on the nature of the need (CE12; CE15); or modeling of a system in which intermediate logic is placed between the CPU and the main memory (CE4). The dissertations in this subset solicit answers that explain how the analysis of memory solutions or proposals for new memory systems contribute to the optimization of memory and thus, overall performance of computer systems.

At the level of *memory technologies*, ten questions address memory optimization in relation to the known limitations of specific technologies in the memory hierarchy (Table 41).

CE1	What memory architecture mitigates the drawbacks of NAND SSDs (slow random write performance) while leveraging their performance advantages (excellent read write latency)?
CE2	How can designers build memory allocation policies to manage the distributed on-chip memory resources at a high level?
CE3	How can transactional support be provided for fast, non-volatile memories that exploits their raw performance and makes programming easy?
CE9	What are the possible approaches to designing and analyzing robust low voltage SRAM?
CE10	What are reliable, low-power methodologies for SRAM memories?
CE11	(1) What are the undesirable design traits of DRAM? (2) How can their effects be mitigated?
CE16	What approach should be taken to dynamically set supply voltages and refresh cycle for Dynamic Random Access Memory (DRAM) and 1T1C embedded Dynamic Random Access Memory (eDRAM) in order to reduce power consumption?
CE17	What are various angles on optimizing the on-chip memory of embedded systems to improve performance without increasing power consumption or die area?
CE19	How can the spatiotemporal interactions in LLC capacity management be exploited to improve CMP's performance?
CE20	How can PCM memory, given its long write latency, high write power and limited write endurance, be successfully applied?

**Table 41. Computer engineering: Queries of rationale/explication about memory optimization – memory technologies**

As computing contexts and use cases continue to put more and more demands on computing systems, the limitations of existing memory technologies become obstacles to faster processing. This subset of *memory optimization* questions, about *memory technologies*, addresses the limitations of existing memory technologies or the integration of new technologies, by: identifying the limitations of DRAM memory (CE11); seeking solutions for already-known obstacles of existing or emerging memory technologies such as the high power consumption of DRAM (CE16) and SRAM (CE9; CE10), the inefficiency of write operations for Phase Change Memory and other non-volatile memory technologies (CE3; CE20); the need for higher performing, low-power on-chip memory (CE2; CE17; CE19), or the slow random write performance of NAND steady state devices (CE1). This category of question content conveys the expectation that the answers explain why and how the proposed solutions overcome the known problems of these memory technologies.

Four questions are formulated in relation to *memory models* (Table 42).

CE5	What algorithm can effectively enforce stricter memory models in parallel processors, such as the sequentially consistent memory model?
CE6	What dynamic optimization techniques, driven by models of shared data and cache use, can be developed for disparate layers of the memory hierarchy?
CE7	What model of cache memory can be developed that eliminates context switch misses?
CE8	What is an efficient alternative model to existing coherence mechanisms that still maintains shared memory?

**Table 42. Computer engineering: Queries of rationale/explication about memory optimization – memory models**

These questions take a model-driven approach to optimizing memory, which has become a major obstacle to performance because of the increasing demands that parallel processing, the simultaneous execution of a problem by multiple processors, puts on the memory system. Memory consistency models are the interface between the programmer and the shared-memory system, determining the order in which memory operations will appear to execute. The memory model “affects programmability because programmers must use it to reason about the correctness of their programs,” as well as “the performance of the system because it determines the types of optimizations that may be exploited by the hardware and the system software” (Western Research Laboratory, 1995). The questions seek model-driven optimizations of the memory hierarchy as a whole (CE5; CE6; CE8) or for a single level of the hierarchy such as cache memory (CE7). By posing queries of (6) *rationale/explication*, the questions communicate an expectation that the answers explain how the proposed models or model-driven optimization techniques address the limitations of current memory models.

One question seeks to optimize a hardware element, *memory circuits* (Table 43).

CE14	How should logic circuits and their signal representations be configured in order to allow low power, nonvolatile dense memory and logic with minimal connections to CMOS?
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**Table 43. Computer engineering: Queries of rationale/explication about memory optimization – memory circuits**

In response, a new type of magnetic memory and logic circuit that is simpler to integrate into the memory system, this dissertation demonstrates why and how it should be applied

to offset the disadvantages of the current technology (CE14). This is the only dissertation that takes a hardware approach to the problem of memory optimization.

One dissertation poses a *(11) correlation – memory and B* question, where *B* is locomotion in a virtual reality system (Table 44).

CE13	Whether the atomic locomotion movements in a virtual reality system with a semi-natural locomotion interface require a user's spatial cognitive resources (working memory).
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**Table 44. Not computer engineering: Queries of correlation about memory and *B***

In CE13, working memory is used as a measure of the cognitive resource requirements of certain types of movements typically engaged by users of virtual reality systems and correlated to manipulations of the user interface and field-of-view. This query-subject pairing requires the answer to show that the user's working memory increases and decreases in conjunction with atomic locomotion movements in the virtual reality system.

**6.5.2 Discussion.** The query-subject analysis of computer engineering question content is decisively uniform: *(6) rationale/explication* queries are posed about different approaches to *memory optimization*. The questions in computer engineering dissertations present as what- or how- questions. They ask, what is the solution or what approach can be taken towards arriving at a solution to the problem of memory optimization, or stated differently, how should the problem solved? The what- and how- questions of computer engineering research on memory are all variations on a theme: how can computer memory be optimized? Specifically, they ask how memory can be optimized according to whatever definition of optimization is set forth in the framing of the problem statement, such as when asking, “How should hybrid DRAM-PCM memory systems be designed that provide robust and consistent memory performance without sacrificing energy?” (CE15). How- questions can seek understanding of current memory systems, as when asking “How do parallel applications interact with hardware?” (CE6), but mostly they ask

how something can or should be done. What- questions are of a two types: those that ask what the problem is (CE11; CE18) and those that ask what approach should be taken to solve the problem (CE1; CE12; CE16) or, more directly, what the solution is (CE8; CE10). This query-subject pairing indicates that the known memory-related subject of inquiry in computer engineering is *memory optimization* (subject); what is unknown is the (6) *rationale/explication* (query) for the proposed optimizing solution.

Only one dissertation in the sample utilizes a different query-subject pairing: a query of (11) *correlation* about *memory and B*. Similar to the single instance query-subject pairings in neuroscience and literature, this could indicate an area of emerging or waning domain interest, a steady-but-minor area of interest, or a poorly formulated question, in relation to domain standards. The uniqueness of this query warrants special attention as to whether it belongs in the computer engineering domain, which otherwise is so homogenous in its question content. Though drawn into the sample because of its classification under the subject of “computer engineering” in the ProQuest Dissertations and Theses database, an interview with the author reveals that this is due to a technicality, in which doctoral students in his doctoral interdisciplinary program receive their degree from their dissertation chair’s department. In his case, his degree was issued from the computer engineering department, but he situates his research in the virtual reality community rather than in computer engineering. The question content analysis identifies this case as an outlier relative to the rest of the sample, which, with additional information, is determined to be outside of the computer engineering domain. This example again indicates that the query-subject analysis is able to identify those knowledge products that are outside of the domain norms or cross domain boundaries,

though further analysis or reference to the researchers or to subject experts is needed to determine the reason for its abnormal question content formulation. In this case, further investigation indicates that this particular dissertation indicates a situation in which the supporting domain structures, in this case, the institutional rule that doctoral students in an interdisciplinary program are affiliated with their advisor's academic department, lag behind the more fluid nature of research center- and lab-based research.

**6.5.3 Summary.** The analysis of the computer engineering question content demonstrates that the indeterminate situation regarding memory in the domain are variations of a singular indeterminacy. While the types of systems and use cases are many, this single question describes the single indeterminate epistemic situation that computer engineering has about memory, in which the goal of *memory optimization* is known (subject), but the (6) *rationale/explication* for the proposed solutions are unknown (query). Computer engineering questions poses queries of (6) *rationale/explication* about *memory optimization* at the level of *memory systems*, *memory technologies*, *memory models*, and *memory circuits*, with each level representing a different approach to determining how it can be optimized to improve system performance.

## **6.6 Comparing content of domains' questions about "memory"**

A side-by-side comparison shows the differences in the question content of neuroscience, literature, and computer engineering research on "memory" (Table 45). Query-subject pairings with only one question instance have been omitted in order to present a clearer picture for domain comparison.

Query	Subject		
	Neuroscience	Literature	Computer Engineering
<i>First order: Properties</i>			
1. Existence/affirmation-negation			
2. Instance/identification			
3. Substance/definition	Neural correlates of memory (3)		
4. Character/description	Role of $X$ in memory (14) Neural mechanisms of memory (15)		
5. Function/application			
6. Rationale/explication	Memory models or instruments (4)	Literary uses of memory (10) Literary construction of memory (5)	Memory optimization (19)
<i>Second order: Comparisons</i>			
7. Concomitance			
8. Equivalence			
9. Difference			
<i>Third order: Contingencies</i>			
10. Relation			
11. Correlation			
12. Conditionality	$Y$ and Memory (11)		
13. Biconditionality (causality)	$Z$ and memory (9)		
<i>Extra order: Other</i>			
14. Deliberation			
15. Acquaintance		Nature of memory (3)	
16. Other			

**Table 45. “Memory”-related question content in three domains**

The distinct patterns of query-subject pairings show the three domains to be clearly differentiated by their question content profiles, which are a representation of the indeterminate epistemic situations relative to “memory,” or the known unknowns, that motivate inquiry in each domain. Both neuroscience and literature are divided into two distinct orders of questions about “memory.” Neuroscience asks about the first order properties of memory and the third order contingent relations between memory and various phenomena of impairment and enhancement. The questions in the first order produce knowledge of the neurobiological properties of memory, while the third order questions produce knowledge about its contingent relations to phenomena of

enhancement, like cognitive interventions, and phenomena of impairment, such as diseases and disorders. Literature poses first order questions of how literary works use and construct memory, while extra order questions inviting acquaintance with memory. First-order queries produce knowledge of the properties of literary memory by asking, why or how does literary memory have the attributes that it does? Extra-order queries invite direct experience of memory through direct engagement with works of literature.

There is a significant division, in the sequential classification scheme, between first-order questions and third-order or extra-order questions, prompting the question of whether these distinct orders of questions in literature and neuroscience should be considered as separate domains, or sub-domains, or fields, or paradigmatic approaches, or by some other label. On this matter, the question content analysis takes no position; the query-subject profiles emerging from question content analysis are not meant to draw hard-and-fast domain boundaries. The purpose of the analysis is to group like research with like, thus providing a conceptualization of the different kinds of question content in the sample. It is up to the discrimination of subject experts to then determine where domain boundaries lie with regards to the question content areas, if determine of boundaries is indeed the goal. To take the literature sample as an example, do the critical and creative bodies of research constitute different content areas in a single domain, or two separate-but-related domains? This is a matter for domain members to decide, most likely with referral to more explicitly social dimensions of the knowledge production, such as the informal and formal practices of scholarly communication, the structures of the domain's institutions, and other factors. Domain boundaries are naturally in flux over time, but also are drawn differently at any given moment in time, depending on the

perspective from and function for which the boundaries are being drawn. The analysis does not provide a final, static representation of a knowledge domain, but provides a snapshot profile of question content that can serve as a starting point for the identification of domain boundaries from a particular perspective.

In contrast to the neuroscience and literature research, computer engineering research is unified in its question content matter, posing only *(6) rationale/explication – memory optimization* questions. The single query-subject pairing indicates that computer engineering research about memory is tightly focused, with all questions being variations on a single underlying question: how can computer memory be optimized to improve system performance? In computer engineering research on memory, memory optimization is the clear goal, but the approaches to optimization memory are multiple: through an overhaul of the *memory system*, optimization of the individual *memory technologies* at all levels of the memory hierarchy, analysis and development of *memory models* for the whole hierarchy, and development of new hardware component such as *memory circuits*.

Overall, the distinct patterns of query-subject pairings in each domain support the premise that domains can be differentiated by the content of their questions. Each domain has a distinct pattern of query-subject pairings, which are a representation of the domain's indeterminate epistemic situations relative to memory according to the known unknowns that constitute the content of domains' questions. Of all the query types in Dillon's (1984) classification, only queries of *(6) rationale/explication* are utilized across all three domains. In neuroscience, queries of *(6) rationale/explication* are posed about *memory models or instruments*, producing knowledge of why and how the proposed

models and instruments serve the research-related purposes for which they have been developed. Similarly, computer engineering queries about *memory optimization* utilize queries of (6) *rationale/explication* to explain why or how the optimizations that that have developed overcome the identified obstacles to efficient memory performance. Literary questions utilize the same query type, but to explain why and how literary texts construct and use memory as they do.

One issue for future research raised by the question content analysis in these three domains is whether query type is wedded to domains regardless of the topic of study. If the sample were drawn in regards to the topic of “language,” for instance, would the same query types appear? We can imagine that literature would employ the same queries as it does for “memory,” queries of (6) *rationale/explication* that ask why and how literary texts demonstrate the properties of language, and queries of (15) *acquaintance* that invite direct experience of language through sensory perception of literary texts. In computer engineering, we can imagine that queries of (6) *rationale/explication* would ask about why and how certain programming languages should be used over others. One could imagine the identified neuroscience query types as applying to the study of language as they do to memory. With three such contrasting domains, the query types seem that they might hold, regardless of subject. On the other hand, comparison of more similar domains or sub-domains within any single domain, effectively “zooming in” on the topic of research, may shift the query-subject pairings as finer distinctions are made. The definition of domains’ query types may depend largely on the scale of the initial domain definition or selection of domains for comparison. This conjecture requires empirical verification.

It is important to emphasize that the analysis of domains by question content does not make any judgments on the quality of the included research, but merely indicates how typical the question content is in the given sample. If a query-subject pairing is used by a high number of dissertations, it is safe to say that the question content area represented by the pairing is of central interest to the domain. However, if a query-subject pairing is less frequently used, there are several possible explanations in terms of domain interest, as briefly discussed previously. The pairing may represent a question content area of waning interest or, conversely, an emerging area of interest. A variant of this explanation is that the emerging content area is in between domains, either interdisciplinary or multidisciplinary in nature. Query-subject pairings representing a small percentage of the total may also represent a small-but-constant area of interest. The neuroscience content area represented by (6) *rationale/explication – memory models and instruments* questions may be an example of this, a minor but important and continuous area of research in a scientific field in which the tools of measurement and models of experimentation are diverse and rapidly developing and thus subject to questions of validity. Alternately it is also possible, particularly for those query-subject pairings with only a single instance, that its inclusion in the domain sample is actually erroneous, as in the computer engineering sample's single instance of a (11) *correlation – memory and B* question. In both of these instances, historical domain question analysis would help in the definitive identification of outliers and the increasing and decreasing interest in different areas of question content.

The comparison of dissertation research about “memory” in neuroscience, literature, and computer engineering over a five-year period results in a broad

comparative picture of each domain's approach that cannot be definitively proposed as representative of the nature of knowledge production in each domain generally, or even as it relates to "memory" as a topic over time. What can be said, however, is that question content analysis, operationalized as the classification of types of queries about certain subjects, produces a characterization of the domain that corresponds to the representative status of the sample. Within the sample, the question content analysis can also distinguish central question content areas from minor areas. Choosing a sampling frame and size that will most accurately represent the domain of interest, then, is essential to a useful question content analysis. As the perspective on the topic is always relative to the frame, the characterizations will shift according to whether the frame is a single domain or multiple domains, and which multiple domains. This shifting does not detract from the validity of the methodology; rather, it reflects the meta-ontological perspective of LIS as concerned with the ways in which social epistemological knowledge domains structure the universe of knowledge.

## **6.7 Summary of findings and conclusion**

The categorization of question content in this chapter responds to research questions 2a, 2b, and 4a: what is the content of neuroscience, literature, and computer engineering dissertations' questions on the topic of "memory," how do they compare, and what information do the comparisons convey about what to answer? The comparative analysis of question content produces both empirical and theoretical findings: empirical findings about what the individual knowledge domains ask about "memory," and theoretical findings about the phenomenon of scholarly questions. In the empirical realm, the question content analysis of neuroscientific questions about "memory" indicates that

domain inquiry is mainly in two central areas, or two types of indeterminate situations: the basic lack of knowledge about the neural correlates and mechanisms of various types of memory at the neurobiological level, and the relations between memory and other phenomena that impair or enhance memory. A smaller and more peripheral subset of inquiry concerns the indeterminate situation of what models, tools, and instruments are appropriate for the study of memory. The indeterminate situations regarding memory in the literature domain mainly concern the literary use and construction of memory, with a lesser interest in the direct knowledge and experience of memory. Computer engineering research centers on a single indeterminate situation in its myriad forms: the optimization of memory in computer systems. Each knowledge domain differs in what they ask about “memory” and the level of unity within the sample chosen to represent the domain.

In the theoretical realm, questions are shown to be comprised of a *subject*, the entities in the world about which an epistemic determination is being made, and *query*, the type of epistemic determination being made. While the *subjects* of questions are unlimited, the *query* types are limited to the ordered classification scheme created by Dillon (1984). Together, the *subject-query* pairings are shown to be an effective way of classifying questions based on what they ask about memory. This definition focuses on the epistemic function of questions: that their primary purpose is to communicate the “known unknown” of inquiry, the indeterminate situation that is seeking to be resolved by the asking of the question. The indeterminate situation expressed by the question content conveys the content-related requirements for the answer that should follow: it should resolve the indeterminacy, transforming the indeterminate situation into a determinate one. Furthermore, the indeterminate situation is defined relative to the

knowledge domain as a social unit of inquiry, rather than relative to the isolated individual. From this social epistemological perspective, the paradox of the question – that one must know enough to know what can be known – is no paradox at all, but simply a truth that reflects the social nature of inquiry as the process by which knowledge is produced.

Having established that the three scholarly domains can be differentiated by their question content and that the query-subject pairings form picture of what domains ask about memory, the next chapter compares how different domains ask, as manifested in question form, and what question form conveys about how to answer.

## CHAPTER 7: QUESTION FORM

### 7.1 Introduction

This dissertation proposes that one way out of the question paradox (Flammer, 1981) that has stymied research about questions in library and information science is to recast questions as social epistemological tools of inquiry rather than as cognitive indicators of individuals' information needs. In reference to the individual questioner, questions are defined as linguistic devices or tools used to make epistemic determinations about the world (Derr, 1982), or as expressions of a cognitive gapped picture of reality and the will to resolve it. We adapt these definitions to the domain level of discourse, defining questions as epistemic devices, tools used to transform indeterminate situations into determinate ones, in the context of knowledge domains as social units of knowledge production. As questions are the tools by which knowledge is produced, it follows that knowledge domains should be differentiated by the questions that they ask. This dissertation seeks to investigate how domains compare according to their question formulations on a common topic and what the comparisons convey about the answers that follow and the assumptions that precede the question.

Chapter Six: Question content analyzes the content of the question formulations in neuroscience, literature, and computer engineering dissertations about "memory" and determines that each domain has a distinct profile of what they ask about memory. The neuroscience, literature, and computer engineering question content expresses the indeterminate situations, the "known unknowns" of "memory," according to query-subject categories. Neuroscience inquiry into "memory" is organized around three main

categories of indeterminate situations, while literature is cleanly divided into two, and computer engineering is narrowly focused on variants of one indeterminate situation (Table 46).

	Query	Subject
Neuroscience	3. Substance/definition	Neural correlates of memory (3)
	4. Character/description	Role of $X$ in memory (14) Neural mechanisms of memory (15)
	6. Rationale/explication	Memory models or instruments (4)
	12. Conditionality 13. Biconditionality	$Z$ and memory (9) $Y$ and Memory (11)
Literature	6. Rationale/explication	Literary uses of memory (10) Literary construction of memory (5)
	15. Acquaintance	Nature of memory (3)
Computer engineering	6. Rationale/explication	Memory optimization (19)

**Table 46. Summary of “memory”-related question content in three domains**

The epistemic function of the question formulations is to express the indeterminate situations motivating inquiry and to call for answers that resolve the stated indeterminacies. By categorizing question formulations according to query-subject pairings, the epistemic function of question content is revealed.

In erotetic terms, questions have a logical structure in addition to communicative function (Brożek, 2011), which structure conveys the level of knowledge that the questioner has about how to fill the indeterminate situation and what constitutes a resolution. Completive questions are answered by filling the cognitive gap, while hypothetive questions require confirmation or disconfirmation of the hypothesized manner of filling the gap. But at the domain level of discourse, what is of interest is the epistemic structure, rather than the logical structure. The epistemic structure of inquiry conveys the domain criteria for how an answer should be produced in order to justifiably resolve the indeterminacy that is articulated by the question content. Whereas logical structure is manifested in syntactic form, epistemic structure manifests in the *epistemic form* of the question. An analysis of the epistemic forms by which the questions are

presented shows whether and how domains can be differentiated according to their epistemic structure, or how they ask questions. In this chapter, I develop a social epistemological definition of epistemic form and identify the forms of questions present in three domains' dissertation abstracts about "memory" in order to explore the relation between question form and the domain-based nature of asking and answering questions.

## **7.2 Method for classifying question form**

When studying questioning in interpersonal contexts such as the reference encounter or, as Dillon (1990) does, in the classroom, courtroom, personnel and other interview contexts, form is defined as a relation between the syntactic and semantic dimensions of the question. Syntactic form refers to the verbalized expression, often offered by the questioner or elicited by an information system or intermediary, of "a cognitive 'need-to-know': the information need" (Horne, 1983, p. 5). In these contexts, the syntactic form of the question is analyzed for what it indicates about the questioner's information-seeking stage and corresponding cognitive state, as, for instance, in the use of open-ended questions to gather information versus the use of closed-ended questions to confirm or deny suspected propositions (Horne, 1990). The syntactic form is interpreted according to the rules of interpersonal communication for the context in question, reflecting the roles of questioner and respondent governing the interaction. In this regard, Dillon (1990) observes question asking and answering as it occurs between teacher and student, trial lawyer and witness, or psychotherapist and patient, among others. Syntactic analysis of question forms studies the verbalized, observable question-and-answer interactions between questioners and respondents for the meaning that is communicated between them.

At the domain level of discourse, the analysis of form primarily concerns the relation between the semantic and pragmatic dimensions of the question. The form of the question is of interest for what it conveys about the relation between the meaning of the question and its use in organizing inquiry towards the production of knowledge. In the social epistemic context of knowledge domains, how individual researchers ask is a function of their level of competence in the knowledge domain in which they are seeking to participate. The form of the question emerges from the ways of the “seeing” and “knowing” of the knowledge domain and are thus inherently social and epistemological in nature, rather than individual and cognitive. The meta-theoretical shift in perspective is from conceiving of question formation as a process of translating an individual cognitive need “to know” (Horne, 1983, p. 5) into terms that the questioner perceives the information system or intermediary can likely answer, to questioning as a practice of inquiry that seeks to follow the epistemological criteria for the production of knowledge within the knowledge domain. The semantic nature of the question is embedded in the pragmatic context of the domain.

The recognition and differentiation of epistemic question forms described in this chapter developed organically from the process of identifying questions present in domains’ knowledge products, which process is reported in Chapter Five: Method for identifying domains’ question formulations. Apart from the obvious difference in the content of the questions, I observed basic differences in the forms that domains presented the questions. For instance, some neuroscience abstracts present their inquiries as driven by hypotheses, while others seemed oriented around a central research question. The difference is not only in the presentation of the question, but the entire epistemic structure

of the abstracts as revolving around the form of the question. While presentation of the question does differ in terms of syntax, what is mainly of interest to the current investigation is the epistemic form of the question rather than the syntactic form. More precisely, what is of interest are the epistemic forms that undergird the syntactic commonalities in the presentation of inquiry in knowledge products such as in the scholarly abstracts that are the main data source of this study.

The development of the concept of questions as having epistemic form is aided by the theory of epistemic games in education. Based on the work of Collins and Ferguson (1993), Sherry and Trigg (1996) define epistemic forms as target structures that guide the inquiry process, showing how knowledge is organized or concepts are classified, as well as illustrating the relationships among the different facts and concepts being learned. Epistemic forms are “models of information,” (Sherry & Trigg, 1996), a way of organizing information into meaningful and recognizable structures that show the relationships between the component entities. One simple and commonplace example is the family tree, which visually organizes family members according to their direct and indirect relationships to other individuals, as well as within the family as a whole. Examples of other everyday epistemic forms include maps, calendars, and recipes. Subject-based epistemic forms include the periodic table in chemistry, historical time lines, mathematical equations, economic graphs, and musical compositions. Each of these epistemic forms structures the visual representation, classification of, and relations between the domains’ ontological entities. A calendar structures time into related segments and places events in relation to each other according to the structure of represented time and visual distances between; the periodic table structures knowledge of

chemical elements, which are defined by their atomic numbers and related to each other by their chemical properties, and electron configurations.

Applying this notion of epistemic form to the topic of question formulation, I propose that questions have epistemic forms that structure the components and relations of inquiry. Where they differ from the epistemic forms discussed above is that components and relations are not visually represented and organized by questions, but are presented and organized at the cognitive level, in the minds of the questioners acting on behalf of the knowledge domain. The epistemic form of the question conveys *how inquiry is organized or components of inquiry are defined, as well as illustrating the relationships among the components of inquiry*. The epistemic form of the question is reflected in the first part of Derr's (1984) definition of the question as a linguistic device or tool used to make epistemic determinations about the world. Whereas question content indicates the epistemic determinations that the questioner seeks to make, question form functions as the device or tool used to make the determination. Questions organize inquiry, and they do so, in large part, through their form. The epistemic form of the question conveys the manner of producing an answer and criteria for evaluating the answer. It provides the knowledge structure within which the components and relationships of inquiry are defined.

The current chapter responds to the research questions concerning question form: (3a) what are the forms of domains' question formulations on the topic of "memory," (3b) how do they compare, and (5a) what information do the comparisons convey about the answers that follow? The abstracts of neuroscience, literature, and computer engineering dissertations about "memory" were analyzed in order to identify the

epistemic forms in which questions are presented. The domains are compared in terms of the question forms they utilize and what the forms convey about how to answer and the structure for inquiry. The epistemic forms were observed to be the central component of the dissertation abstract, with the other abstract segments, corresponding to the other components of inquiry, being definable in relation to the epistemic form of the question. Having identified the epistemic question forms in this manner, the abstracts were then coded, at a sentence phrase level, in order to identify and label the other components of inquiry. The abstracts were then analyzed, grouped by question form, for the relations between coded components of inquiry.

The following sections identify the epistemic question forms as they appear in the three domains and the manner in which the epistemic form conveys the organization of inquiry by defining the components of inquiry and their relations, particularly the form of the answer.

### 7.3 Neuroscience

Three epistemic question forms are present in the fifty-seven neuroscience abstracts: *research question*, *hypothesis*, and *goal* (Table 47). Each question form conveys the epistemic structure of inquiry, the components of inquiry and the relationships between them that determine the form of the answer and the manner of its production.

<i>Form of question</i>	No. abstracts
Research question	28 (49%)
Hypothesis	25 (44%)
Goal	4 (7%)

**Table 47. Neuroscience: Question forms**

**7.3.1 Research question form.** Twenty-eight of the fifty-seven dissertation abstracts present the indeterminate situation in the form of a research question. A *research question* is a question about a topic that is framed, based on a familiarity with the topic, as a perceived knowledge gap or deficit of knowledge about the topic (Farrugia, Petrisor, Farrokhyar, & Bhandari, 2010). The perceived knowledge gap refers to the domain state of knowledge about the topic, rather than individual questioner's state of knowledge. A research question indicates the researcher's perception of "where the boundary between current knowledge and ignorance lies" (Brian Haynes, R., 2006). The components of a research question-driven inquiry are shown in Table 48.

N27: The behavioral and neural effects of emotion regulation on autobiographical memory retrieval	
State of domain knowledge	Individuals' short- and long-term goals can influence the constructive nature of autobiographical memory recall.
<b>Research question</b>	<b>The overarching aim of this dissertation was to examine how emotion regulation goals in particular might modulate autobiographical recall at both a behavioral and neural level.</b>
Research design	In Chapter 1, a new behavioral task instructed individuals to cognitively reappraise the emotions associated with negative and positive events.
Results	Results revealed that such emotion regulation goals influence the emotional and other subjective experiences associated with recall, such that up-regulation instructions were linked to greater reported levels of emotional intensity, sensory detail, and recollection (e.g., reliving), and vice-versa for down-regulation instructions.
Research design	In Chapter 2, functional magnetic resonance imaging (fMRI) was used as participants were instructed to decrease, increase, or maintain the emotions associated with negative autobiographical events.
Results	Decreasing emotional intensity primarily engaged neural activity in regions previously implicated in cognitive control (e.g., dorsal and ventral lateral prefrontal cortex), emotion generation and processing (e.g., amygdala, insula), and visual imagery (e.g., precuneus) during an early phase of recall as participants searched for and retrieved events. In contrast, increasing emotional intensity engaged similar regions as individuals prepared to recall negative events (i.e., before a memory cue was presented) and again as they later elaborated upon the details of the events they had recalled.
Research design	In Chapter 3, individual differences in habitual use of cognitive reappraisal were measured and their relation to neural activity during autobiographical recall was examined.
Results	Results revealed that, even when not explicitly instructed to reappraise, habitual use of reappraisal was broadly associated with neural activity in cognitive control regions (e.g., dorsal and ventral lateral prefrontal cortex, dorsal anterior cingulate cortex) as well as emotion processing regions (e.g., amygdala, insula) across memories that varied in their emotionality and specificity.
Finding	Taken together, these results suggest that short- and long-term emotion regulation goals can influence the construction of autobiographical memories on both behavioral and

neural levels.
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**Table 48. Neuroscience: Structure of a research question abstract**

As an epistemic question form, the *research question* is the component relative to which the other components of inquiry and their interrelations are defined and structured. The Table 48 abstract components are thus described below.

**7.3.1.1 State of domain knowledge.** The existing *state of domain knowledge* regarding autobiographical memory recall is presented in a single sentence: it is known that memory recall is constructive in nature, creating new neural connections between synapses, not just traveling already established pathways, and that it is influenced by individuals' short- and long-term goals. This component of inquiry, generally presented at the beginning of the abstract, summarizes the current knowledge of the topic in order to anticipate the explicit statement of the knowledge deficit that the *research question* seeks to fill. The relationship between the *state of domain knowledge* and the *research question* is one of establishing the knowledge deficit as a rationale for the inquiry.

**7.3.1.2 Research question.** The *research question* drives the inquiry by identifying what knowledge is being sought relative to the state of domain knowledge about the topic; it states the known unknown. In light of existing knowledge that autobiographical memory recall can be influenced by short- and long-term goals, the research question arises from a perceived lack of knowledge about a specific sub-set of goals: emotion regulation goals. Specifically, the research question asks, how might emotion regulation goals in particular modulate autobiographical recall at both a behavioral and neural level? The *research question* intends to increase the *state of domain knowledge* about the topic. It functions to organize inquiry by maintaining a

focus on the boundary between known and unknown. The question formulations presenting as *research questions* are indicated in Appendix C.

**7.3.1.3 Research design.** The approach to inquiry as organized by a neuroscientific research question is a series of sequential or componential experiments that, taken together, give insight into the unknown aspect of the memory-related phenomenon. Description of the *research design* seeks to establish the validity and reliability of each individual study, as well as of the overall logic of the multiple studies towards increasing knowledge of the memory-related phenomenon. The example in Table 48 describes a three-study research design for adequately addressing the research question. The *research question* asks, what is the relationship between emotion regulation goals and autobiographical recall, at behavioral and neural levels? Two studies are described, one designed to measure the behavioral effect of emotion regulation on autobiographical recall, the other the neural effect; a third study is conducted in order to rule out individual difference as explaining the difference in neural activity in the first study. For each, research methods are reported that correspond to the nature of the question: the measurement of emotional and other subjective experiences to study the behavioral effect of emotion regulation on recall and the use of functional magnetic resonance imaging (fMRI) to measure the neural effect. The relationship between the studies is either sequential, with each study building upon the results from the previous study, or componential, with each study providing discrete results that, interpreted together, increase holistic understanding of the phenomenon. The example in Table 48 is both componential and sequential: experiments one and two are componential, in that they approach a common known unknown, the relationship between emotion

regulation and autobiographical recall, at different levels, while experiments two and three are sequential, in that experiment three clarifies the findings of experiment two.

**7.3.1.4 Results.** The abstract reports the *results* of each experiment. The individual studies' hypotheses are confirmed: emotion regulation effects autobiographical recall at the behavioral level, also at the neural level, and the neural effect is not due to individual differences in the habitual use of cognitive reappraisal. Each *result* is a knowledge claim that individually contributes to the domain's epistemic gap regarding the relationship between emotion regulation and autobiographical recall.

**7.3.1.5 Findings.** Together, the individual results are interpreted as a *finding* about the memory-related topic. In a research question-driven inquiry, the epistemological activity of considering how experimental results from the multiple experiments should be interpreted in relation to the *research question* requires another layer of interpretation beyond the interpretation of the results of each individual experiment. The *results* of the three experiments are interpreted together in light of the research question of how emotion regulation goals modulate autobiographical recall. The conclusion is that, "Taken together, these results suggest that short- and long-term emotion regulation goals can influence the construction of autobiographical memories on both behavioral and neural levels." This *finding* reshapes the boundary between the known and unknown of memory in the domain. In some cases, the boundary is simply pushed further out by advancing knowledge of the memory-related phenomenon; the findings "begin to elucidate" (N21) or "contribute to the growing understanding" (N47) of the neuroscientific bases of memory, which in turn leads to more questions. In other cases, the *findings* relocate the boundary entirely, forcing a questioning or rethinking of

previous understandings of the phenomenon. For example, one dissertation's results call into question the traditional memory systems dichotomy that assigns distinct functions to the medial temporal lobe and the striatum in associative learning, concluding instead that the two neural structures dynamically interact during learning (N38).

**7.3.1.6 Summary of research question form.** The *research question* form organizes inquiry as a series of experiments that, interpreted together, shed light on the indeterminate situation. Emerging from the *state of domain knowledge*, it asks questions at the boundary of what is known about memory as a neuroscientific phenomenon. It is known that associative memory exists, but its electrophysiological and neural correlates are not known (N3); it is known that place cells resolve conflicting neuronal signals, but not how (N25); it is known that the hippocampus and medial entorhinal cortex have a role in time and distance coding, but not what the role is. A series of studies is conducted to gather information about the phenomenon, producing some *results*, which are together interpreted as a *finding* that directly responds to the *research question*. The *finding* is evaluated according to whether it increases knowledge of the phenomenon.

**7.3.2 Hypothesis form.** Twenty-six dissertations present questions about memory in the epistemic form of hypotheses. *Hypotheses* are testable and falsifiable explanations for observations, phenomena, or problems in the form of tentative propositions about the relationship between dependent and independent variables. Whereas research questions are formulated to identify the domain's epistemic gap, hypotheses go a step further by conjecturing how the gap should be filled. The indeterminate situation is one of conflicting information (is the hypothesis correct or not?), rather than a gap. Neuroscientific research questions ask about memory while

hypotheses ask about the relationship between memory and other phenomena. Table 49 shows the structure of a typical hypothesis-driven abstract according to the components of inquiry.

N1: Effect of Neuroscience-Based Cognitive Skill Training on Growth of Cognitive Deficits Associated with Learning Disabilities in Children Grades 2-4	
State of domain knowledge	Working memory, executive functions, and cognitive processes associated with specific academic areas, are empirically identified as being the core underlying cognitive deficits in students with specific learning disabilities (SLD). Research has not yet focused on interventions that strengthen the weak underlying neurological processes, which result in students not improving these cognitive deficits.
Hypothesis	<b>Using Hebb's theory of neuroplasticity and the principle of automaticity as theoretical bases, this experimental study examined the effectiveness of a specific 12-week neuroscience-based, cognitive-skills computer-training program on the cognitive processing of 40 elementary students in grades 2-4 with SLD; students, who were equally divided and randomly assigned to the control and experimental groups.</b>
Research design	The independent variable was a computer-based cognitive skill training program. The dependent variables were overall cognitive growth (GIA), executive functions (EF), visual working memory (GV), verbal working memory (WM), processing speed (Gs), short term memory (Gsm), and predicted achievement scores (Brief Reading, Brief Math). Using a multivariate analysis of covariance (MANCOVA) and a 95% confidence interval,
Confirmation/disconfirmation	the study results indicated the experimental group had significantly increased performance over the control group in every skill area examined.
Implications	Implications for positive social change include understanding the impact of cognitive skill training on underlying cognitive deficits of students diagnosed with SLD. Such training can result in increased academic performance.

**Table 49. Neuroscience: Structure of a hypothesis abstract**

The components of inquiry and their relations are described here with an emphasis on the differences from the research question form.

**7.3.2.1 State of domain knowledge.** Similar to the research question abstracts, the abstract begins with the *state of domain knowledge* on the memory-related topic: that students with specific learning disabilities (SLD) have been shown to have cognitive deficits in working memory and executive functions, but that no interventions have been developed that strengthen the underlying neurological processes. Whereas the state of domain knowledge component in the research question-driven inquiries presents a knowledge gap, here it presents an epistemic conflict. Conflicting evidence may present

the need for resolution via experimental means, such as when “neuroimaging investigations into the nature of these deficits” in schizophrenics’ ability to perform working memory tasks “over the last decade and a half have been stymied by inconsistent findings that leave no clear answer as to their cognitive or neural basis” (N54). There may be clinical evidence that suggests the validity of the hypothesis but no direct experimental evidence to back it up, such as in the case where “Memory complaints are regularly reported by ill Gulf War veterans but there is scarce data to verify their complaints” (N10). Or existing research may suggest the hypothesis, such as when “Research in rodents and computational modeling work suggest a critical role for the hippocampus in representing overlapping memories” (N9), but the hypothesis has never been directly tested. The *state of domain knowledge* establishes the need for the experimental research, introduces the relevant variables, and may also provide evidence for the *hypothesis* about the relationship between the variables.

**7.3.2.2 Hypothesis.** The *hypothesis* proposes a relationship between the independent and dependent variables that responds to the epistemic conflict or deficit identified in the *state of domain knowledge* component. In indirect question form, it can be expressed as a whether- statement, asking whether the relationship, between memory and another phenomenon that may impair or improve memory, can be confirmed. The abstract in Table 49 hypothesizes a causal relationship between a cognitive intervention and improved cognitive processing in a group of specific learning disabled (SLD) students who have undergone a twelve-week, neuroscience-based cognitive-skills, computer-training program. Whereas *research question*-driven inquiries interpret the results of a series of experiments to fill the domain’s epistemic gap of memory as a

neuroscientific phenomenon, the *hypothesis*-driven inquiry seeks to resolve an epistemic conflict as to the existence of a relationship between memory and other phenomena of impairment or enhancement. The question formulations presenting as *hypotheses* are indicated in Appendix C.

**7.3.2.3 Research design.** The *research design* by which the *hypothesis* is tested specifies the independent variable (a computer-based cognitive skill training program), dependent variables (overall cognitive growth, executive functions, visual working memory, verbal working memory, processing speed, short term memory, and predicted achievement scores), and the predicted relation between them: a positive relation between those receiving the intervention and the dependent variables measuring cognition and memory. The method of statistical analysis is also stated (multivariate analysis of covariance (MANCOVA) and a 95% confidence interval) in order to justify and communicate the rigor of the results. Unusual or new methods and research designs are paid particular attention, such as the development of novel training paradigms for the study of memory in mice (N13), or the use of music as a retrieval cue for emotional memories (N14). In cases where a cause and effect are being inferred from an animal model, such as the development of a model of prenatal alcohol exposure in mice (N7), the animal model is described in detail in order to justify the inference of results between animal experimentation and human memory. Above all else, the *research design* is described in order to expose the logic by which the *hypothesis* is being experimentally tested.

**7.3.2.4 Confirmation/disconfirmation.** The results of experimentation are stated as *confirmation/disconfirmation* of the hypothesis. In Table 49, the results show that the

experimental group had significantly increased performance over the control group in every skill area examined, which confirms the prediction that a twelve-week neuroscience-based, cognitive-skills computer-training program would improve the cognitive processing of 40 elementary students in grades two through four with specific learning disabilities. In the case of results that do not achieve statistical significance, the hypothesis is disconfirmed or rejected. In comparison to the descriptive finding that results from a research question-driven inquiry, confirmation or disconfirmation of a hypothesis makes a pronouncement on a pre-determined set of possible results, the statistical likelihood that there is or is not a relation between various phenomena of impairment and improvement and memory performance. The *result* resolves the epistemic conflict presented by the hypothesis.

**7.3.2.5 Implications.** The *results* are interpreted in terms of their *implications* for the epistemic conflict about the memory-related phenomenon implied in the *state of domain knowledge* and *hypothesis*. Confirmation of the hypothesis, that the training intervention will improve cognitive processing of students with specific learning disabilities implies that such training can improve academic performance, has *implications* for positive social change. In other dissertations, the confirmation or disconfirmation of hypotheses has implications for the current understanding of a memory-related phenomenon, such as when finding that amphetamines enhance emotional memory encoding and consolidation but impair retrieval suggests the reconsideration of the use of amphetamines for treatment of post-traumatic stress disorder (N4). Not all abstracts include an implications component.

**7.3.2.6 Summary of hypothesis form.** The hypothesis functions as the central component of inquiry, in relation to which the other components are defined and related. The current *state of domain knowledge* exhibits some epistemic conflict in its knowledge of the relation between memory and other phenomena. A *hypothesis* is proposed which would resolve the conflict and is tested according to a *research design* that leads to a *confirmation or disconfirmation* of the hypothesis. The result is evaluated according to the correspondence of the research design to the hypothesis and its validity and reliability, leading to *implications* for the domain knowledge of memory or its application.

**7.3.3 Goal form.** Four abstracts present their questions in the epistemic form of a goal. A *goal* is an aim or desired result that the researcher is setting out to achieve through the research, formulated in relation to an epistemic obstacle that the domain faces in pursuing knowledge of a memory-related phenomenon. The epistemic obstacles concern the means of studying or applying memory, rather than the phenomenon of memory itself. These dissertations develop models and tools for studying and applying memory. Table 50 shows the structure of a goal-centered abstract, defined according to the components of inquiry.

N46: Validation of Alternative Morris Revision-IV Paragraph for Logical Memory Subtest Older Adult Version	
Problem	Although the Wechsler Memory Scale's (WMS) Logical Memory Subtest is one of the one of the best and most commonly used descriptors of overall memory function and dysfunction, significant evidence suggests its use on repeated assessments, is inadequate due to the overall stability seen in studies of test-retest reliability. This problem has been resolved for earlier versions of the test via the development of alternate test stimuli (Morris, Kunka, & Rossini, 1997).
Goal	<b>The introduction of an updated version of the WMS, the Wechsler Memory Scale-4<sup>th</sup> edition (WMS-IV), calls for additional resources especially for the specialized assessment of older adults.</b>
Tool/ instrument	An alternate paragraph (Morris Revision-IV) for the WMS-IV Older Adult Battery Logical Memory Subtest was developed to meet this need
Evaluation	and shown to be psychometrically equivalent. Through collection of normative data, this paragraph was proven to possess strong interscorer reliability and significant correlations with the original WMS-IV Logical Memory paragraph for older adults.
Implications	This evidence has been used to establish alternate-form reliability of the Morris

	Revision-IV paragraph to the extent that it can be used in place of the original for the clinical practice of memory evaluation.
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**Table 50. Neuroscience: Structure of a goal abstract**

Each component of inquiry is further described in relation to the epistemic question form, the *goal*.

**7.3.3.1 Problem.** The abstract begins by stating the research *problem*, the epistemic obstacle that the domain faces in their pursuit of knowledge about memory. In Table 50 the problem is that the most recent version of a commonly used measurement tool and descriptor of memory function and dysfunction, the Wechsler Memory Scale – 4<sup>th</sup> Edition, is in need of alternate test stimuli for its repeated use in assessing older adults' memory. The *problem* sets the context for the formulation of a *goal*, which is an actionable objective towards solving the problem. The problems are sometimes explicitly stated, as in this example, but are often implicit in the statements of the goals, as when proposing “a computational cognitive neuroscience model...which models episodic memory based on the human brain” (N53) or “novel paradigms involving the integration of conventional and ethologically relevant forms of reinforcement in the study of fear conditioning in rats” (N22), which imply the lack of said model or paradigm as the problem.

**7.3.3.2 Goal.** As the epistemic form of the question, the *goal* is the central component in relation to which each of the other components is defined. In response to the problem, the goal identifies what needs to be done in order to find a solution or to move beyond the domain's obstacles towards the desired epistemic state. The goal in the abstract above is to create additional resources for the WMS-IV especially for the specialized assessment of older adults. Other goals in the sample include to “develop the adaptive training for patients with low visual working memory (VWM) capacity to

improve cognitive abilities and healthy individuals who seek to enhance their intellectual performance” (N32) and to “develop novel paradigms involving the integration of conventional and ethologically relevant forms of reinforcement in the study of fear conditioning in rats” (N22). The questions presented as goals, indicated in Appendix C, generally ask, “What tool can be developed to meet the goal?”

**7.3.3.3 Tool.** In response to setting a *goal*, the answer is produced in the form of a *tool* or instrument of research, techniques or instruments that are used to accomplish a function necessary to attain the goal. The research represented in Table 50 proposes a new tool for the purposes of achieving the goal related to the neuroscientific study or treatment of memory: an alternate paragraph for the WMS-IV Older Adult Battery Logical Memory Subtest is developed for the repeated assessment of older adults. Other tools and instruments in the sample include a computational cognitive neuroscience model of episodic memory in the human brain (N53) and an adaptive training for improving the intellectual performance of individuals with low visual working memory (N32). In other domains, an appropriate reply to the posing of a goal may be a program, protocol, or other design that is applied towards achieving the goal.

**7.3.3.4 Evaluation.** Evaluation is the means by which the tool is determined to have achieved the stated goal. In the example, the implementation of the alternate paragraph takes the form of analysis of normative data for interscorer reliability and is evaluated according to its correlation with the original paragraph that is being replaced. N53 implements the computer model of the brain by running the Morris Water Maze task, “a well established biological experimental test of distal reward learning” and comparing results to biological rat experimental data and other models. The adaptive training for

those with low visual working memory (N32) is implemented in an experimental setting as well. The *evaluation* shows whether and how the tool works to achieve the goal.

**7.3.3.5 Implications.** The conclusion of the inquiry is stated in terms of the *implications* of the tool's ability to achieve the goal: that alternate form reliability of the Morris Revision-IV paragraph has been established and can be used in place of the original for the clinical practice of memory evaluation. In the case of the adaptive training for persons with low visual working memory, the conclusion is that the training can significantly improve cognitive function and may be useful for enhancing the user performance on neuroprosthetics devices (N32).

**7.3.3.6 Summary of goal form.** This small subset of neuroscientific dissertations organizes inquiry relative to the epistemic obstacles that neuroscience faces in the study of memory and its clinical application. New *tools* are designed to meet *goals* related to the *problems* arising in the study or clinical treatment of memory. Through implementation and *evaluation of the tool*, *implications* can be drawn about the utility of the tool or knowledge to the motivating *problem*.

**7.3.4 Discussion.** Three forms of questions have been identified in the neuroscience sample of dissertation research on memory. As epistemic forms, they are differentiated by how they structure the components and relations of inquiry. Chief among the components and relations of inquiry is that of the "question" to the "answer." Each epistemic question form has a corresponding answer form; together, they constitute the basic epistemic structure of the inquiry, in relation to which the rest of the components of inquiry are defined. Just as question content, the expression of the indeterminate situation motivating inquiry, conveys the criteria for the answer (that it

resolve the indeterminacy), the form of the question conveys the expectation for the form of the answer. *Research questions* demand answers in the form of *findings* to fill the epistemic gap; *hypotheses* require *confirmation or disconfirmation* to resolve the epistemic conflict, and *goals* solicit the development of *tools* in order to overcome epistemic obstacles.

Additionally, each of the forms of inquiry corresponds to certain question content areas, as described by the query-subject pairings identified in Chapter Six. Together, form and content produce a profile of three areas of memory-related research, as defined by what is being asked about memory (question content) and how it is being asked (question form), indicating the domain's indeterminate epistemic situation and the epistemic structure for how to resolve the indeterminacy (Table 51).

CONTENT		FORM	Co-incidence
Query	Subject		
2. Instance/identification 4. Character/description	Neural correlates of memory Neural mechanisms of memory Role of <i>X</i> in memory	Research question	87.5% (28/32)
6. Rationale/explication	Memory models or instruments	Goal	100% (4/4)
11. Conditionality 13. Biconditionality	<i>Y</i> and memory <i>Z</i> and memory Memory and <i>A</i>	Hypothesis	95% (20/21)

**Table 51. Neuroscience: Question profile**

The first form in which the question presents is the *research question*. Research questions emerge from familiarity with the state of knowledge in the domain related to the phenomenon of interest. They identify a domain knowledge deficit and poses what-or how- questions to fill the knowledge deficit. They do so by means of a series of experiments designed to produce sequential or componential results that, when interpreted together in relation to the knowledge deficit, produce findings that fill the domain's epistemic gap, thus extending the state of knowledge about memory. The *research question-finding* structure is indicative of **descriptive inquiry**. This form of

inquiry is concerned with description of the nature of memory as a physical phenomenon. It seeks basic scientific understanding of phenomena such as memory: what they are, what are their parts and processes, how they are organized, and how they function.

The query-subject pairings that describe question content in *research question-finding* dissertations provide a snapshot of the point at which we encounter descriptive neuroscientific research on memory. Several dissertations ask queries of (2) *instance/identification* about the *neural correlates of memory*. This indicates that much of the initial work of identifying the different types of memory, differentiated according to their neural correlates, or patterns of neural activity, has already been accomplished. Neuroscientists have a strong understanding of the different types of memory, their basic functions, and what they look like in the brain. The focus of the research has moved on to describing the neural mechanisms of memory, or how memory actually functions at the neural level. At an even finer level of description, researchers are also seeking to know the *role of X in memory*, where *X* can be defined at the *anatomical* level (e.g. hippocampus, medial entorhinal cortex) or *neuronal* level (e.g. proteins, RNA). By posing *research questions* that identify the boundary between what is known and unknown and producing *findings* that continue to push the boundary further out, the neuroscientific phenomenon of memory is being mapped out.

The second question form identified in neuroscientific dissertation research about memory is the *hypothesis*. The *hypothesis* question form offers an explanation for observed phenomena in the form of propositions about the relationship between dependent and independent variables. Like *research questions*, *hypotheses* emerge from the state of domain knowledge about a phenomenon, but rather than seeking to fill a

knowledge deficit as research questions do, they seek to resolve an epistemic conflict by isolating the relationship relative to independent and dependent variables that can then to subjected to correlative analyses or controlled experiments in order to get *confirmation or disconfirmation* of the hypothesized relationship. The *hypothesis-confirmation/disconfirmation* form of question and answer frames **determinative inquiry**. In contrast to descriptive scientific knowledge of the neuroscientific bases of memory, this type of knowledge is about the conditional (whether or how if *P* then or if *Q* then *P*) or biconditional (whether or how if *P* then *Q* and if *Q* then *P*) between memory and other phenomena.

While hypotheses are occasionally used in conjunction with queries of (4) character/description in situations where enough is known to produce an epistemic conflict, the predominant correspondence is with (12) *conditionality – Y and memory* questions and (13) *biconditionality – Z and memory* questions. The relationship between memory and the other phenomena may vary in strength and direction, with conditional inquiries generally concerning the causal relationship between phenomena and enhanced memory and biconditional inquiries the likely causal relationship between phenomena and impaired memory. Together, form and content describe the subset of neuroscience that is interested in the negative effect of memory and age, diseases and disorders, and traumatic brain injury on memory, as well as the causal positive effect of cognitive interventions, drugs, and other phenomena such as stress on memory. By formulating *hypotheses*, which are whether- questions, about these relations, the epistemic conflicts related to the tentative relations are resolved.

The third form of question in neuroscientific research about memory is the *goal*. *Goals* are formulated in response to a *problem* in the domain, either related to the ability to conduct research on memory or the clinical treatment of memory-related problems. *Goals* articulate the aim or desired result that the researcher is setting out to achieve to overcome the *problem* in the form of what- questions, asking, what *tool* will achieve the goal and thus solve the problem? The appropriate form of reply to a *goal* is the development of a *tool*, an instrument or technique that is designed, implemented, and evaluated in order to establish that it meets the established goal. The *goal-tool* form of question and answer describes **prescriptive inquiry**. This form of inquiry is essentially pragmatic, aimed at solving specific memory-related domain problems rather than producing knowledge of the phenomenon of memory or its relations to other phenomena.

Goals produce knowledge in the form of (6) *rationale/explanation* of how *memory models or instruments* solve the pragmatic problem: how a new type of animal model integrates conventional and ethologically relevant forms of reinforcement in the study of fear conditioning in rats (N22), or how a computational cognitive neuroscience computer model enables the study of episodic memory of the mammalian brain (N53). The *goal-tool* form of question and answer will be discussed further in relation to the computer engineering domain, for which this is the primary form of inquiry.

**7.3.5 Summary of neuroscience forms.** Three question forms are identified in the neuroscience sample. Paired with the corresponding answer forms, they describe three distinct epistemic structures for organizing the components of inquiry and their relations. *Research question-finding* inquiries produce descriptive knowledge of the neural bases of human memory by formulating questions to fill the epistemic gaps of

domain knowledge about memory. *Hypothesis-confirmation/disconfirmation* inquiries produce contingent knowledge of relations between memory and phenomena of impairment or enhancement such as age, diseases, traumatic brain injury, cognitive interventions, and drugs, by formulating hypotheses about how to resolve an epistemic conflict. Finally, the *goal-tool* form of inquiry produces practical knowledge by formulating goals to overcome the domain's epistemic obstacles to the study of memory or its clinical treatment. Together, the three basic form-content areas constitute a question profile of neuroscientific research about memory.

## 7.4 Literature

Two epistemic question forms are found in the sample of 20 literature abstracts: topic and theme (Table 52). The two forms are distinguished by the manner in which they organize inquiry, as manifested in the components of inquiry and relationships between the components.

<i>Form of question</i>	<i>No. abstracts</i>
Topic	17 (85%)
Theme	3 (15%)

**Table 52. Literature: Question forms**

**7.4.1 Topic form.** Seventeen of the twenty literature abstracts express their questions as being about a topic. The *topic* question form is utilized in critical literature dissertations to establish an epistemic focus for the inquiry. Similar to the neuroscientific use of the research question form, the topic represents the gapped epistemic picture of memory in the domain that is seeking to be filled, but through the critical analysis of literary texts rather than scientific experimentation. Table 53 shows the structure of a typical *topic*-driven literature abstract according to the components of inquiry and their

relations.

L5: History as Myth and Memory: Bassani, Ginzburg, Levi, and the Re-membering of Fascism	
Topic	In my dissertation, "History as Myth and Memory: Bassani, Ginzburg, Levi, and the Re-membering of Fascism" I examine how post-war literature has affected the ways in which Italy has dealt with the memory of Fascism's twenty year rule.
Methodology	I begin by analyzing both the political and the cultural components that contributed to
Premise	the emergence of a dominant Resistance narrative in the immediate post-war years, focusing in particular on the role that Neorealism played in the formation of this narrative in Renata Viganò's novel <i>L'Agnese va a morire</i> , and Roberto Rossellini's film <i>Roma città aperta</i> .
Theory	Through my reading of Benedetto Croce's historicism, as well as theories of cultural memory by scholars such as Pierre Nora, Maurice Halbwachs, and Jan and Aleida Assmann,
Premise	I show how Giorgio Bassani's <i>Il giardino dei Finzi-Contini</i> , Natalia Ginzburg's <i>Lessico familiare</i> , and Primo Levi's <i>Il sistema periodico</i> created an alternate and competing memory of the Fascist <i>ventennio</i> .
Thesis	I finally conclude that after World War II, the position of Italian Jews became a privileged one from which to explore moral and ethical issues concerning the period of transition that followed the conflict, as well as to question dogmatic truths on the public memory of the war.

**Table 53. Literature: Structure of a topic abstract**

Each component in the abstract is described in relation to the *topic* as an epistemic form.

**7.4.1.1 Topic.** The abstracts generally begin by describing the *topic* of the research. *Topic* is defined in the literature domain as the matter being discussed, the matter within a text, set of texts, discourse, or conversation. The topic serves to provide the inquiry with an epistemic focus, informing methodological choices such as the selection of texts for analysis (do they pertain to the topic?) and analytical approach to the texts (how should the texts be analyzed, relative to the topic?). In the example in Table 53, the *topic* is “how post-war literature has affected the ways in which Italy has dealt with the memory of Fascism's twenty year rule.” The literature domain’s questions presenting in *topic* form are indicated in Appendix C.

**7.4.1.2 Methodology.** Descriptions of *methodology* describe the approach to the literary texts by which the textual evidence is produced in support of the argument being made about the *topic*. In the abstract above, the brief methodological statement identifies

a cultural phenomenon as manifested in literary form (“the political and cultural components that contributed to the emergence of a dominant Resistance narrative in the immediate post-war years”), the texts selected for analysis (“Renata Viganò's novel *L'Agnese va a morire* and Roberto Rossellini's film *Roma città aperta*.”), and the analytical focus (the role that Neorealism played in the formation of the dominant Resistance narrative in the selected texts). Methodological statements in other abstracts also describe the rationale for selection of literary texts (L3; L8; L14; L15), the framework for analysis (L9; L10), methods for reading the texts (L10; L14; L15), and methods of presenting the textual analyses (L12; L19).

**7.4.1.3 Premise.** The argument constructed about the *topic* is built upon *premises* or propositions. In the example above, the *premises* are: that a dominant Resistance narrative emerged in the immediate post-war years; that Neorealism played a role in the formation of this narrative in certain texts selected for critical analysis; and that another set of texts created an alternate and competing memory of the Fascist *ventennio*. Throughout the topic-driven abstracts, the *premises* consist of the propositions related to the *thesis* about “memory” that result from the critical readings of the literary texts: premises about how and to what effect authors use characters (L6), shared tropes (L15), narratives (L15; L11), genre (L3; L20), and subjectivity (L1; L14).

**7.4.1.4 Theory.** In addition to describing *methodology*, the abstract in Table 53 identifies the *theories* of “Benedetto Croce’s historicism, as well as the theories of cultural memory” as shaping the argument about the role of literature in relation to history and cultural memory. Literary theories are the systems of related ideas that serve as the critical lenses through which works of art are viewed and discussed. They provide

a body of values and assumptions about the texts that shape the types of premises that the thesis statement can build its conclusion upon. The abstracts in the literature sample employ theories of historicism (L5; L9), ecocritical theories (L11), postmodernism (L6; L10; L20), and theories of memory (L15), to support the *premises* leading to the *thesis* statements.

**7.4.1.5 Thesis.** Questions about the topics are answered in the form of a *thesis*, a statement built upon *premises* that must be proven in order for the conclusion being made in the thesis to be upheld. *Thesis* statements are original arguments made about the topic, constructed from their interpretation of the selected literary texts. The *premises* that emerge from the literary analysis in Table 53 build to the thesis statement, that: "...after World War II, the position of the Italian Jews became a privileged one from which to explore moral and ethical issues concerning the period of transition that followed the conflict, as well as to question the public memory of the war." Serving as the conclusion to the argument that rests upon the outlined premises, the *thesis* statement is typically located at the end of the literary dissertation abstract. The *thesis* statements in this sample make arguments about how literary texts construct, or reconstruct (L10; L20), "forget" (L4; L12; L3) or disrupt forgetting (L18), or to subvert dominant discourses (L2; L19), thus reflecting on how literature engages with memory but also on how memory engages literature, pushing the boundaries of form, narrative, genre, and subjectivity.

**7.4.1.6 Summary of topic form.** The majority of literature dissertations in the sample organize inquiry by selecting an epistemic focus, the memory-related *topic*, for the construction of an argument to be made based on analysis of selected literary texts. The *methodology* shapes the approach to the texts and the shape of the argument, while

*theory* offers a framework for understanding the relationship between memory and text, history, cultures, and subjectivity. These create a lens for textual analysis, from which the *premises* of the argument, as backed by textual evidence, can be constructed. The *thesis* statement stands as the conclusive statement of the argument.

**7.4.2 Theme form.** Three abstracts in the literature sample present the content of their memory-related questions in the form of a literary *theme*, a central thought or idea that recurs or is incorporated throughout a literary work. These are the creative writing dissertations, two novels and a collection of short stories that identify memory as a central theme of the works. Table 54 shows the structure of one of the *theme*-driven abstracts, according to the three main components of this type of inquiry.

L16: <i>Veiled Men</i> : A novel	
Topic	<i>Veiled Men</i> is about a woman's struggle to regain her sense of belonging, having lost her memory after being injured in a violent attack.
Theme	<b>The focus of the novel involves the collectivity of memory and the way patriarchal culture ignores and ultimately punishes women's anger and desire. The protagonist's scattered patches of memory, which she discovers are not her own but those of her loved ones, suggest that that history is a shared experience.</b>
Interpretation	Multiple narratives including letters, diaries, orally transmitted stories and gossip reflect the multiple selves women inhabit when seeking to belong to patriarchal culture and act autonomously within it. The protagonist, Kate, realizes that her anger and her sexuality have moved her husband and family to blot her out, to impose an identity upon her more palatable to them, after her assailant has made her a blank page. Through her search among the textual remains left by friends and family, culminating in the discovery of her husband's secret diary, she is able to identify herself and her attacker, and revise her identity in a position of power.

**Table 54. Literature: Structure of a theme abstract**

Each component is described in relation to the *theme*, which, as the epistemic form, organizes the inquiry.

**7.4.2.1 Topic.** The abstracts begin by describing the basic *topic* or plot of the literary fiction work, what it is “about.” *Veiled Men* is about a female protagonist’s struggle to regain her identity after a violent attack leaves her with amnesia (L16).

Another novel in the sample describes its plot as being about the protagonist’s quest to

reunite the romantic relationship he had with his fourth-grade teacher (L7). The third dissertation, a set of short stories, is about “the importance of myth, memory, tradition, and place within a Southern context” (L17). Whereas critical literature dissertations define “aboutness” relative to a *topic*, the creative writing dissertations define it in relation to literary *themes*.

**7.4.2.2 Theme.** The *themes* of a literary fiction text are the central ideas explored in a literary work, as presented in the text by the author and interpreted by the reader. The memory-related *theme* emerges from the author’s production of the creative work, providing an epistemic focus for the writer’s exploration via production of the text. In the abstract above, the *themes* are the collectivity of memory and punishment of women’s anger and desire by patriarchal culture. Other *themes* in the literature sample include “memory and memoir, sports iconography, gender roles and community” (L7) and “characters’ animalistic nature and their desire to maintain traditions that are on the cusp of fading out entirely” (L17). The questions presenting as *themes* are indicated in Appendix C.

**7.4.2.3 Interpretation.** In response to the implicit presentation of the question as a literary *theme*, readers produce knowledge in the form of an *interpretation* of the theme as a general idea or meaning of the work. The interpretation points back to the theme by describing the ways in which the theme is revealed: through plot points or character development (L7); through the use of narrative techniques (L16); or by playing with language, genre, or form (L16; L17). In *Veiled Men*, the theme of “the collectivity of memory,” that “history is a shared experience,” is revealed through the use of multiple narratives and textual remains that “reflect the multiple selves women inhabit when

seeking to belong to patriarchal culture and act autonomously within it” (L16). The literary interpretation of the work constitutes the explanation or explication of what the work means through an apprehension of theme, context, form, narrative, symbolism, characters, imagery, tone, and other dimensions of the work.

While authors generally do not interpret their own work for the reader, most creative writing doctoral programs require presentation not only of the created work of literary fiction, but evidence of the writer’s understanding and execution of their craft in the form of a critical reflection of their own work. This takes the form of a critical essay, serving as an introduction or accompaniment to their creative work of fiction, or sometimes takes the form of a separate qualifying exam that situates their writing in relation to their literary influences.

**7.4.2.4 Summary of theme form.** Three creative writing literature dissertations present their questions in the epistemic form of a *theme*. The *topic* of the creative work serves as the context for the development of the work’s *themes*, which function as an epistemic focus for the author’s explorations of the topic. Themes are subject to the reader’s *interpretations*, provided, in this academic context, by the authors themselves in the form of critical reflections on their own creative works.

**7.4.3 Discussion.** Two epistemic question forms are found in the sample of literature dissertations. In combination with the corresponding answer forms, they describe two differing structures for organizing inquiry according to its components and relations. Paired with the corresponding descriptions of question content (Table 55), they form a question profile of the literature domain’s research about memory according to what is being asked (content) and how it is being asked (form).

CONTENT		FORM	Co- incidence
Query	Subject		
6. Rationale/explication	Literary uses of memory Literary construction of memory Cultural memory of literary figure	Topic	100% (17/17)
15. Acquaintance	Nature of memory	Theme	100% (3/3)

**Table 55. Literature: Question profile**

The dominant form in which the literature questions present is the *topic*, a subject, matter, or question dealt with in a text, discourse or conversation. The topic question form is utilized in literature dissertations to provide an epistemic focus for the construction of an argument about a memory-related phenomenon via critical analysis of literary texts. The appropriate response to a question posed as a topic is a *thesis* statement, the conclusion of the argument, formulated based upon a set of premises that are supported by close readings of the literary texts as aided by the lens of literary theories and methodologies for approaching the text. The *topic-thesis* structure describes a type of **critical inquiry**. This form of inquiry dissects literary texts in order to make a critical argument about what the text does or how it functions relative to the phenomena of interest. In regards to memory as one such phenomenon, the content of the topic-thesis inquires is described by the query-subject pairings in Table 55, mainly queries of (6) *rationale/explication* about the *literary construction of memory* or *literary uses of memory*. The query-subject pairings, in conjunction with the topic-thesis form, suggest that the literature domain produces knowledge of how memory is constructed in literary texts and what it functions to accomplish for its agents of remembrance. By proscribing the memory-related *topics* as the matter of interest in critical readings of a literary text or group of texts, the literature dissertations result in *thesis* statements about how memory functions in literary texts and how literary texts, in turn, use memory.

The second form of question is the *theme*. Themes are the central thoughts or

ideas that recur or are incorporated throughout a literary work, functioning to provide an epistemic focus for the author's exploration, here of memory-related phenomena, in the production of a creative work. The answer to a theme takes the form of the reader's *interpretation* of the theme or themes in the context of reading the literary texts that have been produced, but is provided by the author in the dissertation abstract due to the requirements of the academic context. The *theme-interpretation* structure characterizes **creative inquiry** in the literature domain. This form of inquiry seeks to foster direct experience of abstract phenomena such as memory by posing queries of (15) *acquaintance* that produce direct, unmediated knowledge of the nature of memory, knowledge that is produced by the reader's interpretation of the theme.

*Topic*-driven critical inquiries produce descriptive knowledge of how memory is constructed in literary texts and how the texts use memory to challenge history, reclaim the present, and imagine the future. *Theme*-driven creative inquiries produce direct knowledge of the collective nature of memory through an invitation to become acquainted with the work of literary fiction that is presented. The difference is between Wilson's (1983) concepts of "first-hand" and "second-hand" knowledge. Knowledge is of two types: that which results from a person's first-hand experience, the body of one's own ideas as framing one's encounters with the world, or knowledge as gained second-hand by depending on cognitive authorities for knowledge outside the range of direct experience (Wilson, 1983). Critical *topic-thesis* literary inquiries produce second-hand knowledge, subject to scholars' critical consideration of whether cognitive authority can be conferred onto the dissertation authors and their research. Creative *theme-interpretation* literary inquiries produce texts that are sources of first-hand knowledge. In

reading and interpreting the novels and short stories, readers are experiencing memory themselves and thus constructing knowledge of the nature of memory in an unmediated, direct fashion.

**7.4.4 Summary of literature question forms.** Two question forms are found in literature, corresponding to two forms of inquiry. *Topics* provide an epistemic focus for the construction of a critical argument about memory's functions and uses in literary texts. *Themes* provide an epistemic focus for the production of a creative work of fiction about the nature of memory, which is then subject to interpretation by the readers. The two epistemic question-answer structures and their corresponding content produce a question profile of the literature domain's approach to memory as two sides of the same coin: criticism and creation.

## 7.5 Computer engineering

Two epistemic question forms are identified in the computer engineering abstracts about memory: *goal* and *hypothesis* (Table 56). The *goal* question form provides a framework for inquiry in relation to which all of the other components of inquiry are identified and defined. A single anomalous dissertation, incorrectly categorized as belonging to the computer engineering domain, employs the *hypothesis* form.

<i>Form of question</i>	<i>No. abstracts</i>
Goal	19 (100%)

**Table 56. Computer engineering: Question forms**

**7.5.1 Goal form.** Nineteen of the twenty abstracts in this domain present the question in the epistemic form of a *goal*. The goal question form has already been discussed as describing a small subset of neuroscience dissertations about research and clinical treatment of memory, but will be further discussed here, as it is the sole form,

excepting one outlier, employed in the computer engineering sample. The *goal* is the central component in computer engineering abstracts, serving as the organizing component in relation to which the other components of inquiry are defined. Table 57 shows the structure of a typical computer engineering abstract.

CE10: Low-power methodology for fault tolerant nanoscale memory design	
Problem	Millions of mobile devices are being activated and used every single day. For such devices, energy efficient operation is very important; low-power operation enables not only long battery time but also improves energy efficiency of the servers that communicate with the mobile devices. However, reduced noise margin due to low-power operation and process variation due to nano-scale transistor feature sizes increase the number of errors in both mobile and server devices. Thus, low-power issues and reliability are strongly related.
Goal	<b>This work focuses on reliable, low-power methodologies for SRAM memories. It is the first to consider SRAM cell optimization for power and reliability simultaneously.</b>
Tool	The main contributions are the following. To guide parametric hard faults, this work addresses energy optimality and yield considering redundant spare rows and columns. This work also describes a method for soft error tolerant low-power memory design using an architectural technique to avoid Multiple Bit Upset (MBU) at low voltages. Then methods using dynamic voltage scaling for soft error tolerant low-power memory designs are investigated.
Evaluation	This thesis results in the improvement of memory power consumption and increases the reliability of memory arrays. Using cell optimization, redundancy utilization, interleaving techniques, and adaptive dynamic voltage scaling, memory reliability is improved and power reduction is reduced by 10%-40% depending on the method applied without sacrificing error tolerance.

**Table 57. Computer engineering: Structure of a goal abstract**

Each component of the abstract is described here in relation to the epistemic nature of the goal.

**7.5.1.1 Problem.** A *problem* states the topic of inquiry, whether existing in the scholarly literature, in theory, or in practice, a condition to be improved upon or a difficulty to be overcome in order to attain some desired end goal or state; it is an epistemic obstacle to greater knowledge of the phenomenon of interest. The central *problem* regarding memory that computer engineering research attempts to solve is, how should computer memory be optimized? Typically, the specific formulation of the *problem* is expressed in terms of limitations in the current memory technologies or

inefficiencies in their implementation in the memory hierarchy. In Table 57, the *problem* is that low-power operations and process variation due to nano-scale transistor feature sizes leads to increased errors in mobile and server devices. Unlike in the neuroscience domain, where *problems* may be implicit in the statement of *goals*, the computer engineering dissertations explicitly state the *problem* that they are addressing in specific detail, outlining the real-world computing use case and the ways in which the memory system is preventing optimal computing performance. The precise formulation of the question as a *problem* serves as the frame for the statement of the *goal*.

**7.5.1.2 Goal.** A *goal* is an aim or desired result that the researcher is setting out to achieve through the research, formulated in relation to an epistemic obstacle that the domain faces in pursuing knowledge of a memory-related phenomenon. All of the computer engineering abstracts are variations on the desired outcome of optimized memory, defined according to the particular type of computing device and use case targeted for study. The specific *goal*, or desired outcome, that guides the inquiry is formulated in relation to the particular use case that constitutes the *problem*, as well as the approach to the problem. The example in Table 57 asks, what are reliable, low-power methodologies for SRAM memories? The memory-related goal is stated relative to the obstacle: as finding a way to maximize low-power operation while minimizing the errors (maintaining reliability) that accompany the technology. The goal is to optimize memory while minimizing power consumption and maximizing reliability. Other examples of *goals* are: to optimize on-chip memory of embedded systems (CE17); to optimize performance and energy of DRAM memory systems (CE11); or to optimize power and reliability of SRAM cell memory simultaneously (CE10). The computer engineering

questions presenting as *goals* are indicated in Appendix C. The what- and how- questions can be converted to goals in the form of to- statements. In CE18 the question is, “what is the behavior of the buffer-on-board memory system?” which can also be stated as a *goal*: “To determine the behavior of the buffer-on-board memory system.”).

**7.5.1.3 Tool.** Questions presented in the epistemic form of a *goal* are answered or responded to by the development of a *tool* to overcome the *problem*. Computer engineering *problems* demand solutions, in the form of the design of *tools* or techniques for optimizing memory. In Table 57, the techniques developed to solve the problem of low power, high reliability memory for mobile devices are: cell optimization, redundancy utilization, interleaving techniques, and adaptive dynamic voltage scaling. The solution is framed directly in response to the formulation of the *problem* statement, describing several of its methods as “soft error tolerant low-power memory design.”

**7.5.1.4 Evaluation.** Finally, *evaluation* of the proposed *tool*, whether the *goal* has been achieved and the epistemic *problem* is resolved, is reported. Does the solution maximize low-power operation and minimize errors, compared to the current baseline system performance? Yes, “memory reliability is improved and power reduction is reduced by 10%-40% depending on the method applied without sacrificing error tolerance.” By the criteria set forth in the statement of the *problem*, the *tool* is validated.

**7.5.1.5 Summary of goal form.** Computer engineering dissertations organize inquiry around a *goal* that emerges from the memory-related *problem*, an epistemic obstacle to attaining desired knowledge of memory. In response to the goal, a *tool* is developed, implemented, and *evaluated* for whether and how it meets the goal and moves towards resolving the *problem*.

**7.5.2 Hypothesis form.** One dissertation abstract in the computer engineering sample presents its question in the form of a *hypothesis* and its answer in the form of *confirmation/disconfirmation* of the hypothesis. CE13 asks whether the atomic locomotion movements in a virtual reality system with a semi-natural locomotion interface require a user's spatial cognitive resources, measured in terms of working memory. The analysis of question content in Chapter Six identifies this dissertation as an outlier, posing a query of (11) *correlation* about *semi-natural locomotion and spatial cognitive resources (working memory)* while the rest of the sample poses queries of (6) *rationale/explication* about *memory optimization*. An interview with the researcher confirms that he does not identify as belonging to the computer engineering domain. The current analysis of question form also identified this dissertation as an outlier, presenting the question and answer in the epistemic structure of a *hypothesis-confirmation/disconfirmation* inquiry, whereas the rest of the sample presents as *problem-solution* inquiry. This suggests that the epistemic form is another useful measure against which questions can be compared in relation to knowledge domain boundaries.

**7.5.3 Discussion.** The single form in which computer engineering questions about memory are presented is the *goal*. The pairing of question form and content produces a question profile of the computer engineering domain's research about memory according to what is being asked and how (Table 58).

CONTENT		FORM	Co- incidence
Query	Subject		
6. Rationale/explication	Memory optimization <ul style="list-style-type: none"> <li>• Memory technologies</li> <li>• Memory systems</li> <li>• Memory models</li> </ul>	Goal	100% (19/19)

	• Memory circuits		
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**Table 58. Computer engineering: Question profile**

Computer engineering research about memory formulates questions as queries of (6) *rationale/explication* about *memory optimization*, further subcategorized as relating to *memory systems*, *memory technologies*, *memory models*, and *memory circuits*. In response to the queries of (6) *rationale/explication*, the research must explain how the optimization tools and instruments function to overcome the specific obstacles to memory optimization for the use case in question.

As discussed in the context of the neuroscience domain, *goals* articulate the desired result that the researcher is setting out to achieve in order to overcome the epistemic obstacle that the domain faces, as presented in the problem. The basic *problem* in computer engineering is that the rate at which processor technology is developing is not matched by innovations in memory systems, which limits the overall performance of the computer system. The *goal* of the research is thus to optimize memory for varied use cases. The appropriate form of reply to a goal is the development of a *tool* that will achieve the goal. Together, the *goal-tool* form of question and answer structure **prescriptive inquiry**. This form of inquiry emerges from a specific use case and aims to resolve the problem; its interest is in the optimal application of memory rather than the knowledge of memory itself. Given the time-bound nature of the goals, in terms of the use cases they refer to and the currency of the technologies, the *goal-tool* form of inquiry does not produce incremental knowledge of computing memory in the form of general principles and abstract truths, but case-based knowledge that is not transferable to other use scenarios. As computer memory technologies and systems continue to evolve and the

societal context and technological infrastructure for computing changes, the knowledge produced by the problem-solution inquiries will become historical and obsolete.

**7.5.4 Summary of computer engineering forms.** One question form is identified in the computer engineering sample. Computer engineers formulate questions in the form of a *goal*, an aim or desired result that the researcher is setting out to achieve in order to overcome an epistemic obstacle towards resolution of a *problem*. The appropriate response is to develop a *tool* to achieve the goal, which should be demonstrated by its *evaluation*. Inquiries utilizing the *goal-tool* structure of inquiry produce prescriptive knowledge of how to solve the problem of memory optimization, a rationale for the tool proposed to attain the goal.

## 7.6 Comparing forms of domains' questions about "memory"

Table 59 summarizes the epistemic forms that questions take in the sample of neuroscience, literature, and computer engineering research on "memory." Each form indicates norms of how to ask and answer questions, which process, of expressing and resolving an indeterminate situation, constitutes inquiry and the production of knowledge.

	Neuroscience	Literature	Computer engineering
Research question	28 (49%)		
Hypothesis	25 (44%)		
Goal	4 (7%)		100% (19/19)
Topic		85% (17/20)	
Theme		15% (3/20)	

**Table 59. "Memory"-related question forms in three domains**

Each domain is distinct in its presentation of the question, with only one form, *goal*, utilized in more than one domain. Neuroscience presents questions in the form of *research questions*, representing the gapped epistemic picture, or known unknowns that the domain is trying to fill about memory as a neuroscientific phenomenon. It also

presents questions in the form of *hypotheses*, which are proposed answers to fill the indeterminate epistemic picture that the domain has of the relationships between memory and other phenomena of impairment or enhancement. Finally, neuroscience presents questions in the form of *goals*, desired aims related to overcoming epistemic obstacles that prevent the resolution of memory-related research and clinical problems. Together, the three forms indicate that neuroscience asks about memory by: identifying the boundary of what is known and extending it by posing *research questions* that organize series of experiments about the “known unknowns”; proposing *hypotheses* to examine the relationship between memory and phenomena that may impair, enhance, or otherwise effect it; and establishing *goals* to overcome obstacles to studying memory and treating memory-related diseases and disorders. The form of the question thus conveys expectations for what constitutes an answer, including the mode of its production and form of presentation. The research questions solicit *findings* to fill the gapped epistemic picture, hypotheses are *confirmed or disconfirmed*, and goals are met by the development of *tools* to overcome the epistemic obstacle.

In the question forms, we see traces of what one dissertation author (N29) describes about neuroscience as an area of study: that it has theoretical and methodological roots in psychology, here represented by the *hypothesis-confirmation/disconfirmation* inquiries about the relation between memory and other phenomena of impairment and enhancement, but has rapidly developed as its own field of study due to the advances and increased accessibility of brain scanning technologies such as positron emission tomography (PET) and magnetic resonance imaging (MRI), represented by the *research question-finding* structure of inquiry. The central role that

technology plays in studying the vastly complex human brain is reflected in the small subset of *goal-tool* inquiries that are interested in memory models or instruments for research.

The literature domain presents questions in the form of memory-related *topics*, a manner of presenting the gapped epistemic picture in a domain that produces knowledge of memory selectively, rather than incrementally as neuroscience does by posing research questions. The topic serves to provide an epistemic focus for the construction of a critical argument built upon analysis of literary texts and culminating in the *thesis* statement. A small subset of creative writing dissertations pose questions in the form of memory-related *themes*, which represent a broader and more vague gapped epistemic picture that gives greater allowance for writers to explore the literary nature of memory. Themes convey that knowledge is produced first-hand, by the reader's *interpretations* of the themes based on direct engagement with the text. At the domain level, the two forms delineate two ways of asking about memory in literature: critically, by framing inquiry as an argument about what certain literary texts say about memory, or creatively, by making inquiry a relation between the author's production of a text with memory-related themes and a reader's interpretation of the textual themes.

Computer engineering uniformly presents its questions in the form of *goals*, aims or desired results for overcoming epistemic obstacles to the study of memory or its clinical treatment. A goal provides an actionable framework for the development of a *tool* that overcomes the obstacle to the desired state of about memory. As computer engineering is concerned with the practical application of computer memory, mainly how to optimize memory systems for higher computing performance, setting a *goal* provides

the framework for the development of optimization techniques and criteria for their evaluation.

Question content is practically limitless in its possible query-subject categories, but question form is likely limited to a small number of variants, of which we have identified five: *research question*, *hypothesis*, *goal*, *topic*, and *theme*. Some, if not all, of these forms are certainly not limited to the domains in which we have identified them. For instance, *goals* are identified as present in neuroscience and computer engineering and are likely to be found in other practically oriented domains or sub-domains. *Research questions* and *hypotheses* are common to all natural sciences and many social science inquiries. It is certain that question form itself will not differentiate a large mixed sample into distinct domains, but in conjunction with question content, it can help to group like research with like on the basis of the method of inquiry in addition to the subject. In combination with question content, form adds a dimension of complexity to the characterization of a domain's questions.

By thinking of other contrasting domains, a few possible forms may be derived: mathematical *conjectures*, *points of law* in jurisprudence, *events* in journalism. An analysis of domains more similar to each other than the ones chosen here may reveal that the epistemic forms can be characterized more finely than the broad characterization of forms in the current study. For instance, *hypotheses* may be more finely characterized according to direction (positive, neutral, negative), or whether simple (one dependent and independent variable) or complex (multiple independent or dependent variables). Question form, like question content, is relative to the sample, which is taken as an indication of validity of this comparative method of analysis rather than a challenge to its

reliability.

This treatment of domains' question formulations as having content and form presents a more specific picture of the nature of inquiry than subject- or topic- oriented descriptions, particularly as it closely relates to methodology. Palmer (2005) notes the importance of considering user groups relative to "types of research problems" when considering how to define a domain:

But, if we are to forge ahead with a domain orientation, it would be advantageous to address the question of gauge, to ask if there are optimal network parameters or ways of defining a user group that are particularly cogent for given types of research problems. For example, understanding the information use patterns of certain cross-domain groupings based on practices and roles (experimentalists/modelers rather than biophysicists; authors of texts/text analysts rather than literary scholars) can help inform the design of collaborative information environments (p. 1140).

Palmer specifically notes that a focus on the type of research problem may distinguish authors of texts from text analysts, rather than grouping them together as literary scholars. Our analysis of question forms in literature confirms this precise differentiation: authors engage in theme-interpretation inquiry that is creative in nature, while literary critics engage in topic-thesis inquiry that is critical in nature. Classifying domains' question formulations according to form, in addition to content, adds an epistemological dimension to the primarily ontological definition of knowledge domains.

## **7.7 Summary of findings and conclusion**

The identification of question forms in this chapter responds to research questions

3a, 3b, and 5a: what are the forms of the domains' question formulations take, how do they compare, and what information do the comparisons convey about how to answer? As with the comparative analysis of question content in Chapter Six, the comparative analysis of question form produces both theoretical and empirical findings. Chapter Six demonstrated a theoretical conception of the question in which question content communicates the domain's indeterminate situations relative to the phenomenon of interest through the formulation of *subject* and *query*, or what the inquiry is about. This chapter further demonstrates that question form conveys how inquiry is organized or components of inquiry are defined, as well as illustrating the relationships among the components of inquiry. Question form and answer form together frame the epistemic structure for inquiry. Adapting Derr's (1982) definition of questions as linguistic devices or tools used to make epistemic determinations about the world to the social epistemological context of knowledge domains, question forms are not linguistic devices or tools, but *epistemic* devices or tools used to make epistemic determinations about the indeterminate situations identified by the question content. The importance of the question as a theoretical concept in LIS is reasserted by showing the ability of the question to convey information about *what* the answer should be about, but also about *how* the answer should be produced.

Chief among the empirical findings, comparison of the dissertation research about "memory" in neuroscience, literature, and computer engineering for the epistemic forms in which questions are presented leads to the identification of five different forms that, in conjunction with the query-subject descriptors of question content, produce question profiles of each of the domains. Neuroscience produces descriptive knowledge of

memory as a neuroscientific phenomenon through *research question-finding* inquiries, and determinative knowledge through *hypothesis-confirmation/disconfirmation* inquiries of the effects of phenomena of impairment and enhancement. A small subset of the neuroscience research also produced prescriptive knowledge through *goal-tool* inquiries about memory models and instruments. Literature is a dual-sided coin, with critical knowledge of how memory is constructed in and used by literary texts being produced by *topic-thesis* inquiries and creative knowledge of memory itself being produced by *theme-interpretation* inquiries. Computer engineering produces prescriptive knowledge of memory optimizations for various use cases through *goal-tool* inquiries. Each question form indicates a different approach to inquiry and the production of knowledge, a different way of “seeing” memory.

Dillon (1990) says that to understand the question, one must understand the answer that follows and the assumptions that precede it. Having analyzed the content and form of questions and what they indicate about the answers that follow in Chapters Six and Seven, we now proceed to ask what the question formulations convey about the assumptions that precede the questions and what they indicate about knowledge domains as the context for inquiry.

## CHAPTER 8: QUESTIONS' ASSUMPTIONS

### 8.1 Introduction

Questions have a fundamental relationship to information (Mackay, 1969; Halloran, 1983) and relevance (Brožek, 2011), but research on questions has long been thwarted by an essential paradox: in order to ask a question, one must know what can be known (Flammer, 1981). This dissertation proposes that the question paradox is a product of the cognitive view of questions as indications of individuals' information needs that can be resolved by recasting questions as social epistemological tools of inquiry. In the social epistemological paradigm, questions are defined as tools used to make epistemic determinations about the world (Derr, 1982) within the context of knowledge domains. Chapters Five, Six and Seven identify the question formulations present in neuroscience, literature, and computer engineering dissertation research about "memory," showing that the domains can be differentiated by the content and form of their questions, or what and how they ask about "memory," and that content and form convey information about what and how to answer. Each domain is shown to have a distinct question profile, composed of categories of question formulations according to content, the indeterminate situations motivating inquiry, and form, the structure for inquiry.

This chapter addresses research questions 4b and 5b about questions' assumptions: what information do the comparisons between questions contents and forms convey about the assumptions that precede the questions? Dillon (1990) describes the practice of questioning as comprised of three ordered elements, each comprised of an act

(of utterance) and a sentence: assumptions, questions, and answers. Having considered questions and answers in the analyses of content and form in Chapters Six and Seven, we now turn to the consideration of assumptions, those presumptions or presuppositions that the questioner is communicating by the question and the asking of it (Dillon, 1990). In this chapter, the differences in domains' question content and form are compared in order to make visible the implicit assumptions of each knowledge domain relative to the production of knowledge about "memory."

## **8.2 Question content and ontological commitments**

In the terms of Kearsley's (1976) insight, that questions convey information not just request it, what information is being conveyed by the domains' question content about the assumptions that precede the questions? Comparative analysis of the query-subject pairings describing neuroscience, literature, and computer engineering questions about "memory" suggests that question content conveys *ontological commitments*: about what can be known about "memory"; its substance, features and relations as the object of research. Knowledge domains are normally defined implicitly by their ontological theories, or theories of what objects exist in the world (Hjørland, 2010). The formulation of question content relies upon the belief in the existence of the objects or phenomena in the world comprising the subject and that the type of determination being made about the objects can be made or known. Question content thus communicates ontological commitments to the existence of certain classes of objects or phenomena with certain types of features and relations between them and other objects or phenomena. Question content conveys information about domains' ontological beliefs.

Derr's (1984) assertion, that questions have "conceptual presuppositions," which are "logically antecedent conditions of questions" (p. 187), can be interpreted as an attempt to identify the ontological commitments of the question for what they indicate about what constitutes a relevant answer. Derr (1984) lists eight types of conceptual presuppositions: existence, identity, properties, relation, number, location, time and action. Dillon's (1984) more extensive and ordered classification scheme of research questions (Table 25) includes the first four of Derr's classes, while the remaining four can be subsumed into the category of "properties." The types of conceptual presuppositions (Derr, 1982) and classes of logical antecedents (Dillon, 1984) are of interest for what they indicate to information retrieval systems designers about what constitutes a relevant answer to the posed question. The current analysis of the ontological commitments indicated by question content is of interest for what they indicate about the domains' construction of "memory" as an object of research. Guba and Lincoln (1994) state the central ontological question as, "what is the form and nature of reality and, therefore, what is there that can be known about it?" (p. 108). In question terms, one could ask, "what is the form and nature of reality and, therefore, what questions can be asked about it?" Or, conversely, "what questions are being asked, and therefore, what can we infer about the form and nature of reality?" In the current analytic scheme, the question becomes "what query-subject pairings are being posed, and therefore, what can we infer about the form and nature of reality in the domain?"

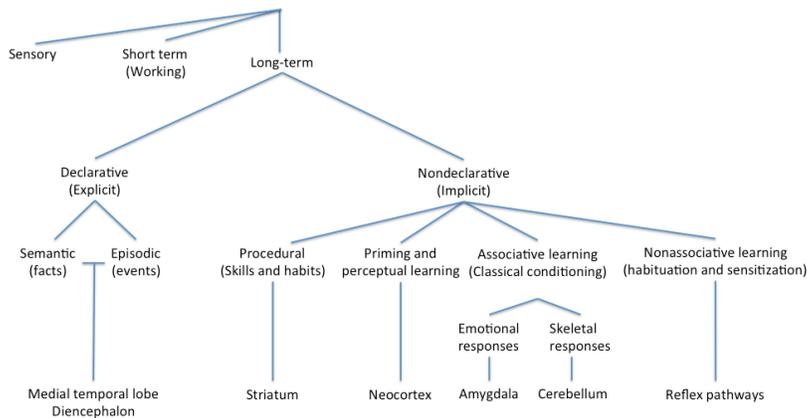
Each of the query-subject pairings within a domain will be discussed in terms of the ontological commitments of the question content category, or what information the category conveys about what "memory" is – its entities, features, and relations. A

summary description will be given of the domain's construction of "memory" as an ontological object of study. Finally, the three domain constructions of "memory" will be compared in order to make more visible the implicit ontological commitments of the domains that constrain the types of indeterminate situations that are expressed through the question content.

**8.2.1 Neuroscience.** The six main query-subject pairings and the questions occupying each pairing can be found in Appendix C, Tables 1 to 3. Overall, the main query-subject pairings utilized in the neuroscience approach to memory indicate ontological commitments to memory as: material, processual, multiple and localized in structure, and malleable.

**8.2.1.1 Memory as material.** Tables 1 and 2 in Appendix C list the neuroscientific questions posing first-order (3) *substance/definition – neural correlates of memory* and (4) *character/description – role of X in memory* questions, where *X* is defined at the anatomical or neuronal level. These questions are ontologically committed to memory as being of material substance, composed of the firing of electro-chemical signals between neurons, the nerve cells of the brain. Each type of memory, whether performed as the recitation of historical facts (semantic memory) or autobiographical events (episodic memory), riding a bicycle (procedural memory), or salivating at the ringing of a dinner bell (associative learning) can be associated with patterns of neural activity. Neural activity is studied at the *anatomical* level of the structures that make up the memory centers of the brain, which is measured as patterns of electrical signals throughout the brain, particularly the hippocampus, prefrontal cortex, and striatum, as well as at the *neuronal* level of the movement of chemical neurotransmitters between

cells. The taxonomy of memory types that have been identified as having distinct neural correlates is shown in Figure 2, with the bottom row identifying the anatomical loci of the type of memory above.



**Figure 2. Memory systems of the brain and their anatomical loci (adapted from Squire, 2004)**

This classification of memory was established based on a long history of empirical work and discussion (Squire & Wixted, 2011), but is not fixed; it represents current domain understanding of the organization of memory, which is subject to change. Nevertheless, it illustrates the biological or material basis of memory, that the different classes of memory are distinguished by their physical location in the brain. At the neuronal level, (4) *character/description – role of X in memory* questions produce descriptive knowledge of genes and their production of the proteins that enable memory and learning. The questions are likewise ontologically committed to the materiality of memory; memory is a neurobiological process that occurs at the neuronal level of the human brain.

**8.2.1.3 Memory as process.** The (4) *character/description – neural mechanisms of memory* questions (Appendix C, Table 3) are ontologically committed to memory as a process of construction, not as a static object that exists in the brain. The questions in this query-subject pairing seek to define the neural mechanisms of information

processing by which acquisition, storage, and recall of memories occur. They construct memory not as an object to be apprehended in a static state, akin to a file that is filed away and pulled out when needed, but as constructive process, occurring in stages of encoding, consolidation, and retrieval, and subject to additional processes such as updating and extinction. As a process, memory is subject to distortion, interference, conflicting signals, and other forces; the mechanisms of these forces constitute the subject of this subset of questions.

**8.2.1.4 Memory as localized and multiple.** Neuroscientific (3)

*substance/definition – neural correlates of memory* and (4) *character/description – role of X in memory* questions (Appendix C, Tables 1 and 2) assume that memory is not a unitary system, but comprised of multiple memory systems, each centrally localized in different anatomical structures as represented in Figure 2. This understanding can be traced back to the seminal case of patient H. M., whose case is often cited as ushering in the modern era of memory research (Squire, 2004). After undergoing an experimental neurosurgical procedure to remove his hippocampi in an attempt to control epileptic seizures, H. M. suffered from a type of amnesia in which he could not make new memories, but did retain his memories from before the surgery and also retained his other perceptual and cognitive abilities. Extensive research on the case of H. M. and other related research has led to the knowledge that there are multiple types of memory (semantic, episodic, procedural, etc.), localized in different anatomical structures of the brain (hippocampus, medial temporal lobe, etc.) and distinct from each other, such that injury to an area of the brain affecting one type of memory does not affect other types.

**8.2.1.4 Memory as plastic.** The (13) *biconditionality – Y and memory* questions (Appendix C, Tables 4 and 5) are ontologically committed to memory as a plastic process. These questions presume that memory can be impaired by conditions that affect the brain such as neurodegenerative diseases and disorders, traumatic brain injury, and the natural effects of age. As a material phenomenon grounded in the biological substrate of the brain, injury to or degeneration of the brain negatively impacts memory. Conversely, neuroscience now also knows that the synaptic connections that form memories are plastic in nature and can be strengthened by cognitive interventions: strategies of self-referential imagination (N20), emotion regulation during autobiographical recall (N27), reward and punishment motivation (N42; N53). Others interventions are pharmacological in nature, such as the effect of amphetamines on emotional memory (N4), alcohol on dentate gyrus dependent learning and memory (N7), and chronic treatment with serotonin on retention and efficiency of rule-guided behavior (N13). These questions are ontologically committed to memory as affected by cognitive processes and biochemical substances, with the effect being observable in behavioral, neuropsychological, biochemical, and neurological terms. The assumption behind these questions is that memory is not a static object, but a plastic process, one that can be influenced by interventions that capitalize upon existing neurocognitive knowledge of learning and memory.

**8.2.1.5 Summary.** The content of neuroscientific questions about memory construct memory as a material phenomenon, reducible to biological events, patterns of electrical signals between neurons and the expression of proteins. Memory is not unitary, but composed of multiple memory systems, with each type being localized in different

anatomical structures. Rather than a static object to be filed away, memory is a plastic process of acquisition, storage, and retrieval, which can be impaired or enhanced by other phenomena that impact the brain. These are the ontological assumptions about memory that are conveyed by the content of neuroscience questions.

**8.2.2 Literature.** Tables 7 and 8 in Appendix C list the questions in the five main query-subject pairing categories of question content in the literature sample of dissertation research about memory. The query-subject pairings indicate that the literary approach to memory is ontologically committed to: memory as abstract, memory as an act, and memory as subjective.

**8.2.2.1 Memory as abstract.** Whereas the neuroscientific conception of memory can be reduced to material, biological events, literature conceives of memory as an entirely abstract phenomenon. Literature questions about memory construct “memory” as something that exists entirely in the minds and imaginations of individuals, with no material substance or shape. This is best evidenced by how literary questions treat memory as crossing physical boundaries of time and space. Memories can be shared by individuals of many generations within a family (L16; L17), among groups of people in different times and places with shared experiences such as those of enslavement (L12; L15) or colonial domination (L4; L8). They can also be shared among persons with common historical contexts, such as those having grown up during Fascism (L5; L19), or even more broadly, those with a cultural knowledge of Italian classical culture (L6) or the events of Mexican independence (L20). Material artifacts, such letters, diaries, other evocative objects, or physical environments may serve as triggers to memory or attempts

to capture or preserve memories, but memory itself exists apart from the material objects, as an abstract phenomenon.

**8.2.2.2 *Memory as act.*** The literary questions about memory are ontologically committed to the act of memory, where to remember the past is to accomplish something in the present. The (6) *rationale/explication – literary use of memory (to challenge historical memory)* questions construct memory as a critical act that serves as a means to reclaim or reassert one’s identity or truth against the power of the official historical account. Memories do not objectively exist but are produced by some person or group of persons, whose act of remembering and manner of remembrance is a choice, not a deterministic outcome of personal or historical events. Literary texts can retrieve memories that have been lost or forgotten in official history (L10), challenge the narrative of the past (L2), and create alternate and competing memories (L5). Through these uses of memory in literary texts, often by those marginalized or oppressed by history, memory serves as a corrective tool applied to official historical narratives.

The (6) *rationale/explication – literary use of memory (to negotiate trauma)* questions are ontologically committed to memory as reconstructive in nature, used to “negotiate the fragmentation that characterizes the traumatic aftermath” (L1) or to “renegotiate the reality of the past, present, and future” (L15). In choosing how and what to remember of one’s past trauma, the victim reclaims agency, which loss is often the defining feature of a traumatic event. In setting the terms of remembrance, the victim’s sense of self is reconstructed in relation to the trauma so that its power can be dissipated.

**8.2.2.3 *Memory as subjective.*** The literary construction of question content is ontologically committed to memory as requiring subjects, agents of remembrance who

continually face the choice of whether and how to remember or forget individual or collective experiences. The agents of memory exist in specific places and times: contemporary Spain and Italy, post-Fascism, post-liberation Zimbabwe, post-apartheid South Africa, and Mexico during centenary and bicentenary commemorations of Mexico's independence. Their memories are subject to their location in time and space: the constructions of gender (L3; L15; L16) and race (L4), possession or lack of power (L8; L12), ethnic identities (L2), cultural history (L5; L6; L9; L18; L19; L20), and place (L17). Agents can assert their agency by choosing how to wield memory relative to their experience and location: to memorialize trauma, disrupt forgetting, renegotiate reality, or create counter-memories. Through these actions, agents reclaim, renegotiate, and reposition their identities with relation not only to the past, but the present and future.

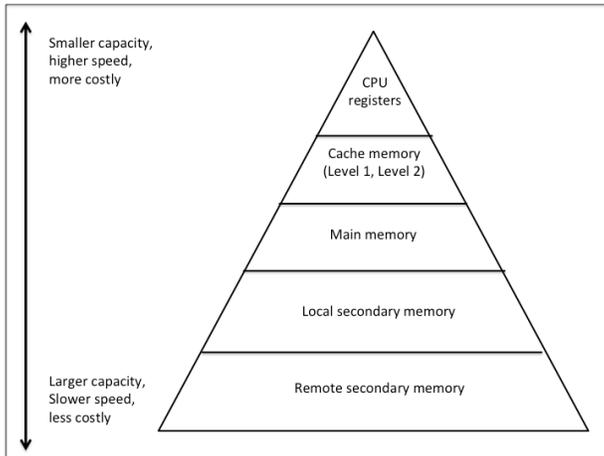
**8.2.2.4 Summary.** Literature questions are ontologically committed to memory as an abstract phenomenon, existing in the minds of individuals, ethnic or cultural groups, generations of families, and nations across the concrete boundaries of space and time. Memory is action-oriented, utilized to accomplish things by the agents of remembrance: to disrupt forgetting, to reclaim one's agency after a traumatic event, to counter the dominant historical record, to create alternate realities. Above all, the literary construction of memory is from the perspective of some specific person or group. Memory requires a subject, whose identity, history, needs and desires shape the nature of the memory and the manner of its application.

**8.2.3 Computer engineering.** The questions in the computer engineering sample are found in Appendix C, Table 11. Computer engineering question content indicates

that the domain is ontologically committed to memory as: abstract process and material object; hierarchically structured; and inherently limited in nature.

**8.2.3.1 Memory as abstract process and material object.** Computer engineering *(6) rationale/explication – memory optimization* questions are ontologically committed to memory as both abstract process and material object. Computer memory systems require both hardware and software, which is depicted by the common metaphor of hardware as machinery and software as instructions; both are required for the machine to run. Software programs are mathematical and logic-driven sets of instructions, based upon models of expected behavior, that execute every action, from monitoring the computer's functionality and booting the operating system to using applications and saving files. A piece of code serves as instructions that initiate a computing process. Yet memory is also constituted of hardware, in the form of the memory technologies, material objects that exist internal, and sometimes external, to the computing processing unit. The term “memory” is used to refer to both the hardware components of the memory system and the software that runs the system. The abstract process relies upon the material object, while the material object is designed for the abstract process.

**8.2.3.3 Memory as a hierarchical system.** The *(6) rationale/explication – memory optimization* questions are ontologically committed to memory as organized into a hierarchical system, with “memory” referring to both the entire system and its component parts. Computer memory systems are hierarchies of storage devices differentiated primarily defined by speed, measured in terms of how many cycles it takes to execute an instruction. The basic memory hierarchy is comprised of, from fastest to slowest: CPU registers, caches, main memory, and disks (Figure 3).



**Figure 3. Computer memory hierarchy**

Specific memory technologies occupy the levels of the hierarchy at the intersection of the axes of cost per byte and access speed, versus capacity. A few questions approach the issue of optimization at the level of the entire memory system, while most pursue optimization by focusing on a specific memory technology at some level of the hierarchy, mostly at the level of main memory technologies such as SRAM or DRAM. Whether by analysis of the entire memory system, proposals for new memory system configurations, or specific optimization techniques for existing systems, the questions are all ontologically committed to the basic hierarchical structure and a belief in its potentially optimized ideal state.

**8.2.3.4 Memory as inherently limited.** The (6) rationale/explication – memory optimization questions are ontologically committed to the inverse relationship between memory capacity and speed, as depicted in Figure 3. The vertical and horizontal axes at which the levels of the memory hierarchy are located place the two main desirable characteristics of memory in tension with each other. Memory technologies with large capacity are slower, while those with smaller capacity are faster. The top tier of the memory hierarchy represents a small amount of fast, expensive memory, while the

bottom tier represents a large amount of slow, cheap memory. The inverse relationship between capacity and speed necessitates the memory hierarchy, the computing architecture in which different types of memory are called upon to perform different memory tasks, depending upon the speed and capacity requirements. Computer engineering questions essentially establish the requirements for building memory systems that reflect the desired balance between capacity and speed for the particular use case scenario in the form of additional constraints or requirements such as cost (CE1, CE4, CE16), power consumption (CE1, CE2, CE9), temperature (CE11; CE16), ease of programming (CE3), and reliability (CE10, CE18).

**8.2.3.4 Summary.** Computer engineering question content constructs memory as both abstract process and material object, reflecting the origins of computer engineering as a hybrid of the computer science and engineering domains. The question content also indicates an ontological commitment to memory as hierarchically structured, comprised of many types of memory with inherent limits, encapsulated by the inversely proportional relationship between memory technologies' capacity and speed.

**8.2.4 Domain comparisons.** Comparison of the ontological commitments of domains' questions about "memory" indicates that neuroscience, literature, and computer engineering have distinct ontological assumptions about "memory" as a topic of research. The ontological commitments of each domains' question formulations are summarized in Table 60 and further discussed in terms of what they indicate about the domains' beliefs related to: the substance and features of memory, their structure, the conditions of their existence, and related phenomena.

Domain	Substance	Features	Structure	Relations	Conditions of existence
NEURO	Material process	Plasticity	Multiple and localized in structure	Conditional or causal	Neural functioning
LIT	Abstract act	Subjectivity; malleability	N/A	N/A	Agent
CE	Abstract process and material object	Limits (speed vs. capacity)	Hierarchical	N/A	Hardware and software

**Table 60. Ontological commitments of question content**

**8.2.4.1 Substance and features of memory.** Comparison of the query-subject pairings makes visible the differences between each domain's definition of "memory," of its essential substance and qualities. At the most basic level, question content reveals ontological commitments to the substance and features of memory. Neuroscience conceives of *memory as a material process*. It has physical substance, taking the form of neurons firing electrical signals across synapses, located in the anatomical structures of the brain, and produced by the genetic expression of proteins. Memory is essentially a biological event. Far from being an object-like picture of a moment to be filed away for later retrieval, though, the question content indicates that neuroscience understands memory as a continual process of encoding, consolidation, and recall, and even possible extinction. Neuroscience questions presume that *memory is malleable* or plastic, that the synaptic connections of memory can be strengthened by use or degraded by disuse or injury. Furthermore, *memory is distributed* across different regions of the brain, not stored in single location, according to type.

In the literature domain, *memory is abstract* in nature, functioning as an invisible but real force shaping of the identities and histories of individuals and collectives. In contrast to the neuroscientific conception, memory cannot be seen, measured, recorded, or reduced to physical matter; it exists in the minds of those who seek to make sense of

their history and identity. The abstract substance of memory is, however, often manifested in the concrete materiality of objects of commemoration or memorialization, or the products of memory such as the literary texts analyzed and produced by the domain. Literary *memory is an action*, wielded by agents to accomplish something in its forgetting, denying, representing, challenging, reconstructing, or imagining the past. Literature questions conceive of *memory as subjective*, as belonging to a specific subject or agent of remembrance. The literary commitment to agency drives the literary characterizations of memory as illusive, porous, and a site of contest.

The computer engineering domain question content conceives of *memory as material object*. Computer memory takes the form of hardware devices – DRAM, SRAM, disk drives, flash drives, etc. – that are physical, tangible objects. They can be installed or removed from a computer system and require electrical currents running through hardware components of the computer in order to execute the read/write instructions. Memory is one component of the hardware that, along with software, constitutes a computer system. Its substance is equally comprised of *abstract processes* in the form of software, the machine-readable instructions that direct the deployment of which memory devices are used for which tasks. Memory has many qualities, desirable and undesirable, which are in constant tension – speed, capacity, cost, ease of programming, volatility, robustness, power consumption, and proneness to error – that can basically be reduced to *two main, opposed qualities: capacity and speed*.

**8.2.4.2 Structure of memory.** Analysis of question content reveals each domain to have a distinct conception of the structure of memory, corresponding to the domain's definition of the substance of memory. Neuroscientific questions presume that *memory is*

*structured according to the localized patterns of neural activity* that are aligned with the type of memory (Figure 2). Memory's structure, its division between sensory, short term, and long term, and the further division of long term memory into declarative and nondeclarative, is subservient to the anatomical structure of the brain and its division of labor. Computer engineering questions rely on the conception of *memory as a hierarchy* of different types of memory technologies, each more or less suited to different types of tasks. As depicted in Figure 3, the different types of memory within the hierarchy are structured according to capacity and speed. Memory technologies that are high speed have low capacity, while those with high capacity have low speed. This basic rule necessitates the existence of the memory hierarchy, in which different types of memory technologies are deployed for different types of tasks in order to optimize the performance of the computer. Of the three domains' questions, only those in the literature domain do not indicate the structure of memory as a significant facet of the phenomenon.

**8.2.4.3 Relations.** A subset of third-order neuroscience questions ask not about memory itself, but the relations between memory and other phenomena, thus expressing ontological commitments to the types of phenomena that are related to memory and the nature of the relationships. In (12) *conditionality – Y and memory* questions, the relations between memory and *diseases and disorders*, *age*, and *traumatic brain injury*, are conditional relationships, meaning that impaired neural activity or performance of memory is determined to be conditional to the presence or absence of the impairing phenomena. The (13) *biconditionality – Z and memory* questions are committed to an

even stronger causal relationship between improved memory and phenomena of enhancement, such as *cognitive interventions* or *drugs*.

Both the literature and the computer engineering abstracts indicate an general ontological commitment to relations between “memory” and other phenomenon, but these relations are not reflected in the content of the questions and are not the direct object of study. For instance, a review of the literature domain’s questions suggests that there is a presumed relationship between the phenomenon of memory and identity, as well as between memory and history, but these relations remain general presumptions and do not constitute the indeterminate situations that the inquiry is seeking to resolve. Similarly, computer engineering questions presume a relationship between computer memory and system performance, but this relationship is not the direct object of inquiry; rather, the direct object of inquiry is the tools of memory optimization that seek to improve memory and thus system performance.

**8.2.4.4 Conditions of existence.** The three domains’ question formulations about “memory” can also be compared according to the conditions under which “memory” exists. The content of neuroscientific questions indicates that *memory requires neural function*. Neuroscience questions are interested in “healthy” or “normal” memory, or that pattern of neural activity that characterizes memory in its unimpaired state, as well as the relationship between phenomena and impaired or enhanced neural functioning. Neural function, whether impaired, normal, or enhanced, is the basic condition of the existence of neuroscientific memory.

The literature domain’s question content indicates that *memory requires an agent* or subject to whom the memory belongs. The memory of an event is not unified,

objective, and factual, but multiple, subjective, and experiential. The existence of agency in relation to memory dictates that individuals or groups must choose whether and how to remember or forget, and opens up the phenomenon of as a site of contest and negotiation between different agents or groups of agents. The dependence upon agency also allows an elision and interchange between individuals and collectives, private and public memories, acceptance and resistance, identity and history, truth and fantasy in literary texts. Literary memory relies upon the agents of its remembrance.

The content of computer engineering questions indicates that *computer memory requires software and hardware* to function. The individual memory technologies, the hardware of the memory system, cannot run without software to coordinate its integration into memory hierarchy and computer system as a whole. Likewise, the software exists specific to the computer system and memory hierarchy that it is written or adapted for. Both are required in order for computer memory, which is required for any and every action, to function.

**8.2.4.4 Discussion.** Comparison of question content in neuroscience, literature, and computer engineering makes visible the differences in the domain's ontological construction of and commitments regarding memory: its substance, features, structure, and conditions of its existence. These differences support the notion that domains ask different questions, according to content or what they ask, and that the differences in question content convey the ontological differences regarding "memory" as an object of research between the domains. Each knowledge domain's perspective offers a specific lens through which memory is viewed, or by which "memory" is seen.

At the same time, by considering multiple domains' ontological constructions of memory as represented by their question content, what emerges is a fuller picture of "memory" than can be had from any single domain's perspective. At times, differing domains can even seem to speak to each other, in the sense that an existing approach or conception in one domain seems to find its way into another domain, as a new line of inquiry, or even an upending of the existing research direction. For instance, early neuroscientific conceptions of "memory" adhered to the "file retrieval" metaphor, in which memories were thought to be stored away like files in a file cabinet, and unproblematically retrieved when needed. At the same time, literary knowledge of memory has long viewed "memory" as a changeable thing: unstable, subject to manipulation, or simply incomplete. Neuroscience has since come to understand what literature has long known: that memory is malleable, that they can be distorted by intentional or unintentional misinformation, through the neural mechanisms of synaptic plasticity, the strengthening or weakening the synapses across which neural connections travel. While computer engineering research is concerned with computer memory rather than human memory, one can reflect on the metaphorical relation between the two types of memory, particularly as the creation and naming of computer memory is a product of human activity, and even more so as the lines between humans and computers as separate entities continue to blur. One can imagine lines of research about, as is already represented in techno-futuristic films and novels, the ability to download knowledge into human brains (the film, *The Matrix*), or the erasing of traumatic human memories (the film, *Eternal Sunshine of the Spotless Mind*), or capturing an individual's memories in order for them to live on by being inserted in another form (Rudy Rucker's novel,

Software). Different domains may speak to each other, either intentionally or coincidentally, in a manner that produces novel directions for inquiry.

**8.2.4.5 Summary.** The comparison of domains' questions, according to their query-subject pairings, demonstrates that questions have ontological commitments about memory's substance, features, structures, relations, and conditions of existence. These ontological commitments, derived from a comparative analysis of question content, produce a picture of domain ontology relative to the state of knowledge about "memory" in each domain. Neuroscience constructs memory as a biological process, multiple and localized in structure, and subject to impairment or enhancement. The literary construction of memory is of an abstract act, wielded by subjects in order to challenge history, or reclaim or remake one's identity. Computer memory is both material object and abstract process, reflecting the substance of computers as hardware and software, structured for maximum efficiency and optimal performance. Comparative analysis of question content produces a profile of what each knowledge domain asks about "memory" and the ontological commitments of those questions.

Simultaneously, the three knowledge domains' conceptions produce knowledge of "memory" as a multi-faceted phenomenon of inquiry: human and machine; resistant yet always subject to change, systematic and structured, but also unordered and elusive. The multi-domain topical approach that is taken by the current analysis is offered as a means of relating different domains' constructions of a shared topic of interest, a way of communicating across discipline-specific languages in a manner that the proliferation of multi- and inter-disciplinary centers, programs, and institutional structures of research

suggest is the current frontier of knowledge production and an important complement to the production of deep subject-specific knowledge.

### **8.3 Question forms and epistemological presuppositions**

While there are multiple query-subject categories of question content in neuroscience and literature, the within-domain categories share similar ontological commitments across domain categories. If differing within-domain categories of question content share ontological commitments, what differentiates them from each other? Within-domain categories of question content may share an ontological reality even between the different indeterminate epistemic situations that constitute the question content, but they differ according to *how* the indeterminate situation is to be resolved. This is manifested in the form of domains' questions about "memory." Reflecting the characteristics of the question as a device or tool for organizing inquiry (Mackay, 1960), question forms are defined by how they structure the components of inquiry towards the production of knowledge. They reflect how epistemic determinations are made, providing a framework for the practices by which knowledge is deemed justified belief. The epistemic form thus communicates the unstated domain assumptions about the nature of producing and justifying knowledge, or the question's *epistemological presuppositions*, "assumptions about the grounds of knowledge – about how one might begin to understand the world and communicate this as knowledge to fellow human beings" (Burrell & Morgan, 1979, p. 2). These are the fundamental, most often unstated assumptions about what can be known and how it is known, centered on the question, "What is the nature of the relationship between the knower or would-be knower and what can be known?" (Guba & Lincoln, 1994, p. 108). Other central questions include: What

are the necessary and sufficient conditions of knowledge? What are its sources, structures, and limits? What makes justified beliefs justified?

Zwart (2008) demonstrates how this comparative epistemological perspective can serve to highlight different ways of knowing in relation to the subject of “nature.” Zwart compares the “epistemological profiles” or “styles” that characters in various works of literature including Herman Melville’s *Moby Dick*, Ibsen’s play “The Wild Duck,” Jack London’s *The Call of the Wild*, and Jules Verne’s *Around the World in Eighty Days*, exhibit in “knowing” plants, animals, and the natural environment: scientific, experiential, and intuitive. Each epistemological profile allows nature to emerge only under certain conditions, which methodological approach forces critical reflection on the structure and reliability of knowledge forms. The comparative epistemological approach is particularly apt for knowledge organization, which is by its definition concerned with understanding the differences between knowledge domains’ in terms of the manner and type of knowledge they produce in the context of organizing the knowledge products of inquiry for intellectual access.

For a question to be valid, and able to be validly answered, its presuppositions must be true; for this reason, one must know a question’s presuppositions, in order to know whether the question is being validly answered (Dillon, 1990). Similar to the determination of questions’ ontological commitments, questions’ epistemological presuppositions are made highly visible in comparison to contrasting domains’ questions. Questions’ epistemological presuppositions, along with the ontological commitments, are what largely constitute the implicit dimension of the question that is the domain context. As a linguistic tool or device, the epistemic forms are defined by their functions related to

the production of knowledge, chiefly in conveying the kinds of claims about memory that can be made in reply to the question, what kind of evidence can be used to support the claims, the kinds of warrant by which evidence may be linked to the claim, and the manner of validating the answer. Each of the domains will be described according to the epistemic forms of their questions and what the forms presuppose about the nature of: “knowing” memory, evidence, and justification. The three domains’ constructions will also be compared in order to make even more visible the epistemological presuppositions that are communicated by the domains’ questions about “memory.”

**8.3.1 Neuroscience.** Tables 1 through 7 in Appendix C list the dissertation questions in each question content category, with epistemic forms indicated in the last column. Neuroscience presents its questions in three epistemic forms: *research questions*, *hypotheses*, and *goals*. All three forms are grounded in the scientific method for producing knowledge, a systematic method for investigating the natural world by making empirical observations, posing questions in the form of hypotheses that potentially explain the observations, testing hypotheses via experimentation, and analyzing the results to form conclusions about the hypotheses. The question forms, when paired with the forms of the answers, define three structures for inquiry that largely correspond to the distinct content-driven areas of neuroscientific research about memory: *research question-finding* inquiries produce knowledge by asking (3) *substance/definition – neural correlates of memory*, (4) *character/description – neural mechanisms of memory*, and (4) *character/description – role of X in memory* questions; *goal-tool* inquiries ask (6) *rationale/explication – memory models and instruments* questions about the study and clinical treatment of memory; and *hypothesis-confirmation/disconfirmation* inquiries ask

(12) *conditionality – Y and memory* and (13) *biconditionality – Z and memory* questions about the relation between memory and phenomena of impairment or enhancement. The three question forms of inquiry are distinguished by their epistemological presuppositions about the nature of: “knowing” memory, evidence for knowledge claims, and justification of answers.

**8.3.1.1 Research question-finding presuppositions.** Twenty-eight of the fifty-seven neuroscience dissertations present their questions in the form of a *research question*, questions about a topic that are framed, based on a familiarity with the topic, as a perceived knowledge gap or deficit of knowledge about the topic (Farrugia, Petrisor, Farrokhyar, & Bhandari, 2010). The responses or answers to questions presented as *research questions* take the form of *findings* that fill the epistemic gap or extend the boundary identified in the research question. As a structure for inquiry, the *research question-finding* form presupposes that knowledge of memory is obtained through scientific observation, beginning with observations of (3) *substance/definition* about the *neural correlates of memory* and progressing to observations of (4) *character/description* about memory’s neural structures (*role of X in memory*) and the *neural mechanisms of memory*. Memory is “observed” according to various methods for measuring biological activity: neurophysiological data about how memory functions in the brain (N24; N50; N28; N37; N3; N8); neuropsychological data concerning its cognitive and behavioral manifestations (N5; N19; N29; N35; N39; N41); neuroanatomical data about how memory is structured in the brain (N30); and sometimes a combination of methods (N38). These observations are technologically enabled, relying on scientific instruments for measuring the biological manifestations of memory such as functional magnetic

resonance imaging (fMRI) scans to measure blood flow or PET or CT scans to measure electrical activity, and laboratory instruments for analyzing brain lesions.

The *research question-finding* structure for inquiry presupposes that experimental results are the primary source of evidence supporting the truth status of the observational findings. Given the technologically enabled nature of “seeing,” how does the scientist know what constitutes an observation of memory? Experiments are conducted in order to measure neural activity during a memory task and compare it to baseline resting neural activity. If the difference between the two states of activity achieves statistical significance, then what is seen achieves the status of an experimental observation of memory. *Research question-finding* inquiries are structured as a series of experiments, anywhere between two and six in number, that are organized as components or sequential parts of one research design intended to make sense of a series of observations in a manner that sheds light on the epistemic gap identified by the research question. The following description of a research design demonstrates that the three experiments seek to verify individual observations, which together produce a *finding* relative to the *research question*, “What are the behavioral and neural variations in semantic memory retrieval?”

In three studies, we found evidence that while conceptual knowledge is grounded in neural substrates, several factors contribute to variations in semantic memory retrieval. In Chapter 2, we used the logic often used in neuroimaging studies of semantic memory by demonstrating overlapping chromaticity effects (e.g., greater response to colored than grayscale stimuli) in the left lingual gyrus for both color perception and color knowledge. Chapter 3 investigated whether the mapping between perception and memory varied across contexts and participants.... In

Chapter 4, we used a training paradigm to investigate the role of feature diagnosticity (i.e., features that best distinguish between two otherwise similar categories) in semantic representations.... Collectively, this work suggests that semantic representations, integral to a memory system often thought of as free of contextual constraints, contain meaningful variations across contexts, people, and use. (N29)

In this example, each of the three component studies demonstrates some type of variation in semantic memory retrieval: color variation, contexts and participants, and features. Together, they demonstrate that while grounded in neural substrates, semantic memory retrieval is subject to meaningful neural and behavioral variations. Each experimental result determines whether what is being “seen” is a scientific observation of the hypothesized memory-related phenomenon. The set of experimental results, interpreted as a group, together offer as evidence supporting the *finding* as a response to the *research question*.

These *findings* are justified as domain knowledge at two levels: at the level of the individual investigation, according to whether they appropriately respond to the question by filling the epistemic gap or pushing the epistemic boundary presented in the *research question*; and at the level of domain knowledge, according to its coherence with what is already known about the memory-related phenomenon. The difference is between justification according to the internal logic of the inquiry and relative to the external state of domain knowledge about the phenomenon. The *finding*, that semantic memory retrieval differs across sources such as contexts, people, and use, is justified according to the internal logic of the inquiry in that it fills the epistemic gap identified by the *research*

*question*, of characterizing the behavioral and neural variations of semantic memory retrieval. At the level of external justification relative to domain knowledge, the *finding* is set in contradiction to the current domain thinking about semantic memory being “free of contextual constraints” (N29). In order to achieve the status of knowledge within the domain, the finding, whether confirmatory or contradictory to what is currently known, must be explained relative to the domain state of knowledge. Contradictory findings may result in a reinterpretation or reframing of previous understandings, or may seek to refute the previous findings through the strength of their own inquiry process.

**8.3.1.2 Hypothesis-confirmation/disconfirmation presuppositions.** Twenty-five of the fifty-seven neuroscience dissertations present their questions in the form of a *hypothesis*, a conjecture about how to fill an epistemic gap identified by the neuroscience domain about memory and formulated as a tentative relationship between independent and dependent variables. Responses or answers to questions presented as *hypotheses* take the form of *confirmations or disconfirmations* of the conjecture about how to resolve the epistemic conflict. As a structure for inquiry, *hypothesis-confirmation/disconfirmation* questions presuppose that knowledge of memory is obtained through experimental testing of hypotheses about the relationship between impaired or enhanced memory and its potential causes. In contrast to the *research question-finding* structure for inquiry, which utilizes experimentation to determine what constitutes an observation of memory, these inquiries utilize experiments or quasi-experiments to test whether a hypothesized relationship can be said to exist between memory and other phenomena. Experiments are the fundamental tool for producing scientific knowledge, which process is characterized by minimization of subjective bias, manifested in the controlled nature of the experiment:

the definition of independent and dependent variables, control of the experimental setting, and careful measurement and interpretation of resulting empirical data. Neuroscientific inquiries posing *hypotheses* about the relationship between memory and phenomena of impairment or enhancement derive knowledge, in the form of *confirmation or disconfirmation* of the hypothesis, by comparing experimental and control groups relative to the memory-related phenomenon of interest. The causal relationship between memory and phenomena of impairment is tested by causal comparative quasi-experiments, whose content is characterized by queries of (12) *conditionality* about Y *and memory*. These causal comparative inquiries seek to assign causality to *diseases and disorders, traumatic brain injuries, age, and individual differences* by testing whether the differences between pre-existing groups' memory activities and performances are statistically significant. Queries of (13) *biconditionality* test hypothesized differences between randomly assigned experimental and control groups in order to determine whether the independent variable, such as *cognitive interventions or drugs*, can be claimed as a causal explanation for enhanced memory. In this manner, *hypothesis-confirmation/disconfirmation* inquiries presuppose that knowledge is derived through experimental or quasi-experimental testing of hypothesized relationships.

The *hypothesis-driven* inquiries rely on empirical measures of memory as evidence supporting the *confirmation or disconfirmation* of the hypothesis. Empirical evidence minimizes subjective bias by being open to examination by other independent members of the knowledge domain of its assumptions, methods of obtaining the evidence, and manner in which the evidence is tied to the hypothesis. The empirical evidence for *confirmation or disconfirmation* of the relationships between memory and other

phenomena takes the form of statistically significant differences in experimental and control groups' measures of memory, whether measured as neural activation, cognitive or behavioral performance, or anatomical features. In the following example, the empirical evidence supporting the *hypothesis*, that retrieval and definition of events from memory differs between older and younger adults, is the comparison of the patterns of neural activity during autobiographical memory retrieval between older and younger adults:

Our results highlight key differences in brain activity during autobiographical memory retrieval in the prefrontal cortex and anterior cingulate, and in the functional connectivity between these regions and the hippocampus. Further, our results demonstrate age differences in event definitions during perception and retrieval. We conclude by highlighting how these findings relate to the processes of memory retrieval and event segmentation. (N26)

The difference in empirical measures of memory between age groups, obtained via experimentation, serve as evidence to support the confirmation of the hypothesis, that there are age differences in event definitions during perception and retrieval. In this manner, the presentation of questions in *hypothesis* form presupposes that the source of evidence for *confirmation or disconfirmation* is empirical measures of statistically significant differences in memory between experimental and control groups.

The *confirmation or disconfirmation* of a *hypothesis* is justified as domain knowledge according to whether the experimental results can be accepted as valid and reliable by domain standards. Reliability refers to the repeatability of experimental findings and is a measure of the objectivity of the scientific method. Validity is of two types, internal and external, and refers to the credibility of the research, with internal

validity referring to the condition that the observed differences between groups can be said to be a direct result of the manipulation of the independent variable, and external validity referring to the ability of the findings to be generalized to groups outside of the experimental setting. In the example above, the experimental result's reliability is established by descriptions of the experimental design, procedures, and data analysis. Internal validity is established by justifying the researcher's choice of instruments for measuring memory and domain-normative use of the instruments and analysis of the resulting data. Finally, external validity is established according to the sampling method and the appropriateness of the scope of the generalization in relation to the sampling method. *Hypothesis-driven* inquiries thus justify the *confirmation/disconfirmation* of the hypothesis as domain knowledge according to the validity and reliability of the research design logic, methods, and procedures used to obtain the experimental results.

**8.3.1.3 Goal-tool presuppositions.** The *goal-tool* structure for inquiry is the single form of inquiry in the computer engineering domain and is described in more detail in Section 8.3.3. Briefly, neuroscience inquiries presenting their questions in the form of *goals*, related to epistemic obstacles to the study of or clinical assessment of memory, respond by developing *tools* for overcoming the obstacles. These inquiries presuppose that: knowledge of memory is obtained through the development of tools for studying or assessing memory; the design of the tool is evidence in support of its attaining status as domain knowledge; and the tool is justified as domain knowledge according to its efficacy in attaining the goal that motivated its development.

**8.3.1.4 Summary.** The three epistemic forms in which neuroscientific dissertations present questions about memory possess differing epistemological

presuppositions about how memory can be known within the domain. Questions presenting as *research questions* presuppose that knowledge of memory is obtained through scientific observation, supported by evidence in the form of several experimental results that, interpreted holistically, form a *finding*. *Findings* are justified as knowledge according to whether and how plausibly they fill the epistemic gap or push the epistemic boundary identified in the *research question* and whether they cohere with the greater understanding of memory in the domain. Questions presenting as *hypotheses* presuppose that memory is known through scientific experimentation, that the source of evidence confirming or disconfirming the hypothesis is statistically significant differences in empirical measures of memory between groups defined by the independent variable (hypothesized causes of memory impairment or enhancement), and that the *confirmation or disconfirmation* is justified as knowledge by the reliability and validity of the experiment. Finally, the neuroscientific questions presenting as *goals* presuppose that knowledge of memory is produced by developing *tools*, which are justified as knowledge by the efficacy of their design in overcoming the epistemic obstacle identified in the *goal*. The three question-answer forms indicate that neuroscience engages three ways of “knowing” memory: through observation, testing of its relation to other phenomena, and development of tools for its study and treatment.

**8.3.2 Literature.** Tables 8 through 11 in Appendix C list the literature dissertation questions by content, with the epistemic form of presentation, *theme* or *topic*, identified in the right-hand column. *Themes* and *topics* represent two related stages or levels of the literary production of knowledge, with *theme*-driven creative inquiry producing literary texts, such as novels or short story collections, and *topic*-driven critical

literary inquiries analyzing the literary texts produced by *theme*-driven inquiries. The two forms differ according to the presuppositions they indicate about: what constitutes knowledge of memory, or the manner of knowing; sources of evidence supporting the answer; and criteria for validation of the knowledge claims as answers to the questions.

**8.3.2.1 *Topic-thesis presuppositions.*** Seventeen of the twenty literature dissertations present their questions in the epistemic form of a *topic* and produce knowledge in the form of a *thesis*. These inquiries presuppose that knowledge is produced by argumentation, the presentation of an argument, defined by Kemerling (2011) as a set of two or more propositions related to one another in such a way that all but one of them (the premises) provides support for the remaining one (conclusion or *thesis*). The propositions in literary arguments offer *rationales or explications* about the *literary construction of memory*, identifying the literary devices by which memory is constructed in texts, and the *literary uses of memory*, interpretations of how the literary constructions serve to accomplish actions such as negotiating trauma or challenging historical memory. These propositions, once logically connected to each other, become *premises* in support of a conclusive *thesis* about memory. Literary knowledge of memory based on argumentation is inferential in nature, relying on logical reasoning to move from the premises, derived by textual analysis, to the interpretive conclusion (*thesis*) of the argument about the literary nature of memory.

*Topic-thesis* inquiries claim the critical analysis of literary texts as evidence to support their arguments about memory. The strength of the argument relies on the quality of the literary analysis: the originality and acuity of the thesis and the clarity and skill with which it is supported as the logical conclusion to the premises. The concluding

*thesis* statement, that “memory and witnessing are deeply entwined with the linguistic, which, by imploding into the poetic, offers the possibility of reconciling the imaginative intervention with the (obliquely) referential,” is supported by literary analysis of “the poetics of traumatic hindsight”:

This thesis will provide a comparative analysis of the poetics of traumatic hindsight and the literary devices that three texts – Anne Michaels's *Fugitive Pieces*, Linda Hogan's *Solar Storms*, and Toni Morrison's *Beloved* – utilize to signify the necessity of a retrospective gaze towards the atrocious past. The thesis investigates the ways in which each text negotiates the fragmentation that characterizes the traumatic aftermath, particularly as a result of the incomplete nature of traumatic history inscribed as absence of knowledge. (L1)

The evidence supporting the claim resides in interconnecting premises about the “incomplete nature of traumatic history inscribed as absence of knowledge,” how the texts negotiate the fragmentation of trauma by employing a “poetics of traumatic hindsight” and “literary devices,” and that these necessitate “a retrospective gaze towards the atrocious past.” As a form of argumentation, the critical analysis of literary texts is secondhand knowledge, dependent on the cognitive authority of another, the dissertation author. Knowledge derives from second-hand experience of memory in the form of critical arguments about the construction of memory or its use in literary texts. The dissertation author’s analyses and interpretations of the literary texts, rather than the texts themselves, are offered as evidence for the memory-related argument presented in the thesis statement.

Literature dissertations asking *topic* questions justify their *theses* about the literary construction and use of memory as knowledge according to the strength of the argument. The determination of an argument's strength is two-fold: it must have true premises and valid inferences (Kemerling, 2011). Evaluating the truth of the premises entails considering whether the premise is reasonably supported by the evidence provided: can the premise be believed, considering the textual evidence provided? If all the premises can be deemed true, then justification is a matter of the validity of the inference between premises and conclusion (*thesis*). In the example above, the researcher infers, from the premises about how the three texts “negotiates the traumatic aftermath” in a manner that necessitates “a retrospective gaze towards the atrocious past,” that “memory and witnessing are deeply intertwined with the linguistic, which... offers the possibility of reconciling the imaginative intervention with the (obliquely) referential.” The status of the thesis as domain knowledge depends on whether this inference meets the domain standard of a valid inference.

**8.3.2.2 Theme-interpretation presuppositions.** Creative literature dissertations are structured according to the epistemic framework of *theme-interpretation* inquiries: they present questions in the form of a *theme* or motif, a central thought or idea that recurs or is incorporated throughout a literary work, and produce knowledge in the form of an *interpretation* of the theme. Posing queries of *acquaintance* about the *nature of memory*, the three creative writing dissertations locate the source of knowledge of memory in the reader's unmediated apprehension of memory as a theme in a literary work of fiction. In other words, readers “know” memory by directly encountering it in the text. Distinct from any of the other forms identified in the three-domain sample,

*theme-interpretation* inquiries produce first-hand knowledge of memory, defined by Wilson (1983) as knowledge that results from direct experience, with the body of one's own ideas framing one's encounters with the world. In reading a novel or short story that has memory as a main theme and forming interpretations of the significance and meaning of the theme, readers produce knowledge based on their own personal experience of memory in the text. Knowledge derives from first-hand experience of the phenomenon of memory in literary texts.

*Theme-interpretation* inquiries presuppose that the literary texts are themselves the primary source of evidence supporting the knowledge claims that take the form of readers' *interpretations* of the literary *themes*. Readers draw upon the content and form of the text, what is being revealed about memory, and how (through what literary devices) it is being revealed, to support their thematic interpretations of memory:

Multiple narratives including letters, diaries, orally transmitted stories and gossip reflect the multiple selves women inhabit when seeking to belong to patriarchal culture and act autonomously within it. The protagonist, Kate, realizes that her anger and her sexuality have moved her husband and family to blot her out, to impose an identity upon her more palatable to them, after her assailant has made her a blank page. Through her search among the textual remains left by friends and family, culminating in the discovery of her husband's secret diary, she is able to identify herself and her attacker, and revise her identity in a position of power.

(L16)

The reader's interpretation is here articulated by the author of the text, due to the requirements of the doctoral degree in creative writing, which requires not only

production of a literary work of creative fiction, but also critical reflection on the work, offered in some supplementary form such as a critical essay that accompanies the dissertation. In the critical essay, the author speaks on behalf of the reader, offering a description of his or her own literary techniques and the intention towards which they are applied relative to the *themes* of the work.

How do readers of literary texts justify their *interpretations* of the memory-related *themes* present in texts? Since knowledge is derived from direct experience of memory in the text, readers' *interpretations* are justified according to the quality of readers' experiences. The depth of experience and force of impact that the text has on the reader is justification for the validity of their *interpretation*. Authors cite the readers' enjoyment and connection with the text as an explicit intention in producing the text, stressing that "the key to good writing is entertainment," that they write to create a "new experience" for their reader (L17), and that they craft the language and structure of text with a desire to "treat" their reader to "fresh language" or by doing something new with plot, instead of "the same old plot line" (L16). Different readers are expected to have different experiences of the text, leading to distinct *interpretations* of the *themes*, but the authority of one interpretation over another is judged by the depth of the reader's experience.

**8.3.2.3 Summary.** The two epistemic forms in which literature dissertations present questions about memory convey differing epistemological presuppositions about how memory can be known in the literature domain. Questions presenting as *themes* presuppose that knowledge of memory is obtained through direct experience of memory, that the source of this direct experience is the literary text itself, and that the knowledge claims, in the form of readers' *interpretations* of the *themes*, are justified according to the

depth of the experience of the text. Questions presenting as *topics* presuppose that memory is known through argumentation of a *thesis*, that the source of evidence supporting the thesis is critical analysis of the texts, and that the *thesis* is justified as knowledge by the truth of the premises upon which it is built and the validity of the inference connecting premises to thesis. Together, the two form-related subsets of literature dissertations suggest that the literary way of knowing memory is both creative and critical in nature.

**8.3.3 Computer engineering.** Table 12 in Appendix C lists the dissertation questions according to the single epistemic forms in which computer engineering questions present: *goals*. Goals are aims or desired results that inquirers set out to achieve through the research, formulated in relation to epistemic obstacles that the domain faces in pursuing knowledge of memory. The response or answer to *goals* takes the form of *tools* developed to overcome the obstacles to domain knowledge. The *goal-tool* structure for inquiry indicates that the computer engineering approach to memory presupposes that knowledge of memory: is obtained through implementation of the tool; relies on the tool's design as its source of evidence; and is justified as knowledge according to its efficacy in attaining the goal.

**8.3.3.1 Goal-tool presuppositions.** What does the computer engineering domain's presentation of questions in the form of *goals* reveal about how memory is known in the domain? Posing queries of *rationale/explication* about *memory optimizations*, computer engineering inquiries locate the source of knowledge about memory in the development of tools and techniques for optimizing memory. The process of writing code, whether designing software to run the computer systems and applications

or architecture of the computer system itself, is an iterative process of analysis, design, implementation, and evaluation. Coding is bound by the constraints of the computer system and its components, as well as the aims or desired functionalities of the tool that is being developed. Whether developing *memory systems*-level approaches to optimization such as hybrid memory systems for servers (CE15), *memory models* for the different levels of the memory hierarchy such as cache memory (CE7), or optimizing techniques for the application and integration of specific *memory technologies* such as SRAM (CE9; CE10), knowledge derives from the coding process, from the design process of creating a solution to inefficient memory.

Questions presented in the form of *goals* require that the answer present in the form of *tools*. The *goal-tool* structure for inquiry presupposes that the design of the tool is the primary source of evidence supporting the proposal of the tool as knowledge. In the following example, the goal of creating a memory system for servers with a small amount of DRAM and large amount Phase Change Memory (PCM) in order to capitalize on their complementary characteristics is met by the proposal of two hybrid memory systems, described according to their design:

In this dissertation, we propose two hybrid memory systems for servers. The first system (called Rank-aware Page Placement or RaPP) is a hardware-driven page placement policy. The policy relies on the memory controller (MC) to monitor access patterns, migrate pages between DRAM and PCM, and translate the memory addresses coming from the cores. The second system (called Rank-aware Cooperative Cache or RaCC) is a software-driven policy for object placement in server clusters that implement cooperative memory caches. RaCC

monitors object popularity and leverages that information in placing the objects.

(CE15)

As an epistemic form for inquiry, a *goal* is an open-ended question; it can be met in many different ways, by the use of many different tools. Given that the number of tools that could be designed to meet a goal is theoretically unlimited, the description of the design of the tool developed and proposed in the research serves as the necessary evidence to demonstrate that the design does indeed attain the goal towards which it is being applied. In the example above, two hybrid memory systems for servers are described: a hardware-driven system called Rank Aware Page Placement (RaPP), and a software-driven one, Rank Aware Cooperative Cache (RaCC). Descriptions of their basic designs, of how they function to implement memory, serve as evidence that supports the proposal of these systems to attain the goal of creating a memory system for servers that combines DRAM and PCM. The details related to how it does reveals the logic and organization of the tool, opening it up to evaluation of manner in which it attains the goal.

Computer engineering dissertations presenting questions in the form of *goals* respond by developing *tools*, in the form of techniques, for memory optimization. Since the nature of development for computer memory is that it is always looking ahead, anticipating the increasing processing demands on computer systems, advancements in memory chip capabilities and processing speeds, and the development of new memory technologies, coding often relies on simulators that allow researchers to develop *tools* for systems that do not yet exist in material form. In order for the *tools* that are developed in relation to the memory-related *goals* to be justified as domain knowledge, the simulator must be accepted as a reasonable representation of the imaginary computer system's

behavior. Researchers may modify pre-existing simulators to meet the criteria of the system that fits the use case that they are designing for, but if no simulator exists that models behavior close enough to the type of system being imagined, the researcher must create a simulator from scratch (CE15). Simulation results are compared to community benchmarks, in order to justify the validity of the simulator and the experimental results that it produces (CE2).

Given that the simulator is accepted as modeling the behavior of the computer system in question, the *tools* produced by *goal-driven inquiries* are ultimately justified as domain knowledge according to the efficacy with which they attain the goal that motivates the research. If the technique for memory optimization succeeds in reaching the specific aim or desired result as specified in the goal statement, then it is justified as knowledge. In order to determine whether the *tool* attains the goal, it needs to be implemented and evaluated in relation to the motivating *goal*. In the above example, the two proposed hybrid systems are implemented and evaluated, which results show:

...that our hybrid memory systems provide robust and consistent memory performance without sacrificing energy. Based on our experience and results, we conclude that Phase Change Memory (PCM) is a promising main memory technology for future servers, especially when combined with a small amount of DRAM. (CE15)

The justification of the two hybrid systems is articulated in relation to the initially stated goal of creating a memory system for servers with a small amount of DRAM and large amount of PCM in order to capitalize on the complementary advantages of each.

**8.3.3.2 Summary.** The computer engineering domain presents its questions in a

single epistemic form, the *goal*. Inquiry driven by a *goal* has distinct epistemological presuppositions about the domain approach to “knowing” memory. Questions presenting as *goals* related to optimization of computer memory presuppose that knowledge of memory is obtained through the development of *tools* for optimizing memory, that the design of the specific tools or techniques proposed serves as the source of evidence as to its status as justified belief, and that the *tool* is justified according to its efficacy in attaining the *goal* that motivates and organizes inquiry.

**8.3.4 Domain comparisons.** Comparison of the epistemological presuppositions of domains’ questions about “memory” indicates that neuroscience, literature, and computer engineering have differing assumptions about how “memory” is known. The epistemological presuppositions of each domains’ questions are summarized in Table 61 and further discussed in relation to: how “knowing” occurs, the relation between knower and known, the sources and functions of evidence, and the nature of justification.

Question form	Domain	Way of “knowing”	Relationship, knower and known	Evidence	Justification
RQ-finding	NEURO	Scientific observation	Objective	Experimental results	Internal logic of inquiry; external state of domain knowledge
Hypothesis-confirmation/disconfirmation	NEURO	Experimental testing	Objective	Empirical measures	Reliability and validity of experiments
Goal-tool	NEURO; CE	Development of tools	Objective/ Subjective	Design of tool	Efficacy in attaining goal
Topic-thesis	LIT	Argumentation	Subjective	Critical analysis of literary texts	Soundness of argument
Theme-interpretation	LIT	Direct encounter	Subjective	Literary texts	Quality of experience

**Table 61. Epistemological presuppositions of question forms**

**8.3.4.1 Ways of “knowing.”** Comparison of the epistemic forms in which domains present their questions about “memory” makes visible the domain-based manner of knowing, the epistemological profile or style of the domain. First and foremost, the

epistemological profile of a domain is defined by asking: what is knowledge in this domain and what are its scope and limits? For *research question-finding* and *hypothesis-confirmation/disconfirmation* neuroscientific inquiries, knowledge derives from direct observation of memory as well as indirect inference of memory based on tests of memory's relations with other phenomena. Both kinds of knowing rely on empirical data, enabled by technologies that are used to “see” memory directly, as with MRI images or PET scans, or to infer its characteristics based on measurements of its cognitive or behavioral manifestations. *Research question-finding* inquiries produce direct-technologically-enabled knowledge of memory, while *hypothesis-confirmation/disconfirmation* inquiries produce indirect, inferential knowledge based on its measureable relations to causal phenomena. Neuroscientific knowledge of memory, according to an interview with a dissertation author, is thus limited by the inherent limitations of the technologies for observing and instruments for measuring memory, as well as researcher competence in the collection of data and its interpretation (N29).

The dependence on technologies and instruments of “seeing” memory accounts for the subset of neuroscientific *goal-tool* inquiries, which seek to develop and validate the tools and instruments of the domain, their appropriate uses, and the interpretation of the empirical data they produce. The nature of neuroscientific knowledge of memory is thus entirely dependent on the tools and instruments for gathering empirical data about memory. Objective scientific knowledge of memory is obtained through the continual development and improvement of tools and instruments and active debate about the interpretation of resulting data. The two question forms, *research questions* and *hypotheses*, are thus united by their reliance on tools and instruments to collect empirical

data about memory yet differentiated by the directness or indirectness of the empirical data; the third question form of *goal* concerns the tools and instruments themselves.

Literary knowledge of memory is also characterized by two question forms that presuppose different ways of knowing: knowing through experience and knowing through argument. Knowledge of the nature of memory is derived, in *theme-interpretation* inquiries, from direct experience with memory, through firsthand *interpretation* of literary *themes* in creative works of literary fiction. To be immersed or actively engaged in a literary text, as a work of art, is to experience propositional truth firsthand, through one's own senses. This form of knowledge is limited in scope by what one can directly experience of memory in the text, as is all firsthand knowledge, but is counterbalanced by the authenticity of direct experience. In contrast, the secondhand knowledge produced by critical *topic-thesis inquiries*, constructs its inquiry as an argument, a series of propositions about memory that emerge from the analysis and interpretation of a group of literary texts, where all but one of the propositions serve as premises leading to the final proposition, a conclusion in the form of a thesis statement. In these inquiries, the scope of knowledge is limited to what can be supported by the analysis of the text. These two ways of knowing, the creative and the critical, both characterize the nature of literary knowledge of memory: as commonly deriving from texts, yet differentiated by whether the knowledge is firsthand, produced on one's own cognitive authority relative to the text, or secondhand, by conferring cognitive authority to another's analysis of the texts.

The computer engineering domain presents questions in the form of *goals* related to memory optimization and responds in the form of developing *tools* to apply towards the goals. Knowledge of memory derives from the process of development that ends in

production, utilization, and refinement of the form of the tool itself; it is in the iterative development of the tool, as means to overcome the epistemic obstacle, that memory is known. Code is written, tested, evaluated, rewritten, and retested, in order to determine the final form of the memory solution. The scope of knowledge of memory in computer engineering is limited by the ability of the simulator to model the parameters of the imagined system, as well as by the requirements of the use case for which the solution is developed.

**8.3.4.2 Relationship between knower and known.** Comparison of the epistemological presuppositions of question forms reveals that the forms differ according to the relationship between the knower or would-be knower and known. *Research question-finding* and *hypothesis-confirmation/disconfirmation* inquiries presume independence between the knower and known, that any would-be knower can objectively “know” memory by following the bias-minimizing logic and procedures of experimental research. The principle of reproducibility that is part of the bedrock of experimental science presupposes that experimental observations and test results are the objective product of research, rather than the subjective view of individual researchers. In contrast, the literature domain’s question forms presume the exact opposite: that the relationship between knower and known is one of necessary dependence, and that what is known about memory depends on the subjective experiences of the knower. Memory cannot be objectively known, but is always filtered through the experiences, existing knowledge, social location, and specificity of the possessor; memories belong to individuals or to groups with similar experiences. This dependence opens up the space in literary texts for multiple and conflicting memories, resistance towards the dominant discourse,

reconstruction of past events, and even the opening up of possibilities for the future.

The *goal-tool* form of inquiry, found mainly in the computer engineering domain but also in the neuroscience domain, presumes that the relation between knower and known is somewhere between dependence and independence. The precise *tools* proposed to attain memory-related *goals* are not the unique possession of the respondent, being, in theory, producible by any domain member, but there is level of individual creativity in the development of the particular tools, out of an infinite number of possibilities, that suggests a relation between knower and known.

**8.3.4.3 Evidence and justification.** The five epistemic forms utilized in the three domain sample convey differing assumptions about what counts as evidence in support of a “memory”-related knowledge claim and what the evidence does in order to support the claim. Evidence is defined as "information bearing on the truth or falsity of a proposition" (Audi, 1999, p. 293), which we situate within a specific knowledge domain. With sufficient evidence, the proposition or knowledge claim is justified as knowledge; evidence is that which justifies belief.

The type of information that constitutes evidence differs according to the form of inquiry. Both *research question-finding* and *hypothesis-confirmation/disconfirmation* inquiries rely on experimental results, the statistically significant differences in empirical measures of memory, as the primary source of evidence. In *research question-finding* inquiries that seek to establish what constitutes an observation of memory, the statistically significant differences are within-individual differences. These quasi-experimental causal comparative inquiries seek to establish statistically significant differences between neural activity or cognitive/behavioral performance during a

memory task and the baseline measure, in order to support the claim that a legitimate observation is being made. Evidence for the neural correlates of a type or aspect of memory or the observation of a neural mechanism are constituted of experimental results that show that there is a significant difference between the neural activity or performance measured during the memory task as compared to before or after the task. In contrast, *hypothesis-confirmation/disconfirmation* inquiries rely on the experimentally obtained, statistically significant between-group differences in neural activity or cognitive/behavioral measures as evidence to support the claim that a causal relationship exists between the phenomenon represented by the experimental variable and memory. For both forms of inquiry, the knowledge claims, about what constitutes an observation of memory or relation between memory and other phenomena, is justified by the validity and reliability of the experiment.

The *topic* and *theme* inquiries both rely on literary texts as sources of evidence for supporting the *thesis* statement or literary *interpretation* as knowledge claims. Where they differ is in the status of the text as a direct or indirect source of evidence. *Topic-thesis* inquiries produce critical analyses of literary texts in which the texts are excerpted, described, discussed, and utilized to build an argument about memory. The evidential status of the literary texts is filtered through the critical literary analysis and is thus an indirect source of evidence, with the critical analysis itself serving as the direct source of evidence to support the argument encapsulated by the thesis statement. In *theme-interpretation* inquiries, the literary texts, in the form of the creative works of fiction produced, are themselves the direct sources of evidence, offered to the readers for their interpretation. Knowledge of memory is justified by readers' direct interpretation of the

memory-related theme within the literary text. For both literary forms, the literary text stands as the central source of evidence, whether directly experienced or indirectly through another's analysis of the texts.

The *goal-tool* form of inquiry is the only form that crosses domain boundaries, employed unanimously in computer engineering inquiries but also employed by a small subset of neuroscience inquiries. In this form of inquiry, the primary source of evidence supporting the proposal of a new *tool* is the design of the tool or technique. By describing the construction of the *tool* and the plan for how it will function to meet the stated *goal*, whether a new instrument for assessing older adults' memory performance (N46) or model-driven memory optimizations for high performance computing systems (CE6), the design of the *tool* justifies its proposal as domain knowledge.

**8.3.4.4 Summary.** The comparison of domains' question and answer forms, which together provide an epistemic structure for inquiry, demonstrates that question forms convey epistemological presuppositions, including assumptions regarding what can be known, its scope and limitations, the relation between knower and known, and the source of evidence and justification. The differences in question forms sketch the epistemological profiles or styles of the domains relative to the study of "memory." The five forms characterize distinct ways of knowing. *Research questions* and *hypotheses* presuppose that knowledge derives from scientific experimentation directed towards discovery or confirmation, while *topics* and *themes* assume that knowledge derives either from direct experience or critical argumentation. The fifth form, *goals*, presupposes that knowledge derives from the development of tools. It characterizes the approach of the entire computer engineering domain, as well as the subset of neuroscience that concerns

epistemic obstacles to the study and treatment of memory. The comparison of forms supports the notion that domains not only ask about different things as embodied in question content, but ask differently, as is embodied in the question forms identified.

At the same time, the three knowledge domains' epistemological profiles emphasize that "memory," as an object of inquiry, is subject to myriad ways of knowing: through observation, testing, argument, experience, and design. Each way of knowing corresponds to certain categories of question content, which is to say that different things can be "known" by different manners of "knowing": each way of knowing brings to light a distinct facet of the phenomenon of "memory." The domain comparative methodology exposes different approaches to producing knowledge about "memory" as a common topic of inquiry, between and within domains, as indicated by the epistemic structures created by their question-answer forms.

#### **8.4 Question relevance and social factors**

Hjørland and Hartel (2003b) characterize knowledge domains as having ontological, epistemological, and social dimensions. Chapter Six and Section 8.2 of this chapter demonstrate that question content gives an indication of domain ontology, in the form of the ontological commitments of the questions' queries and subjects, or *what* the domain knows memory to be. Likewise, Chapter Seven and Section 8.3 of this chapter demonstrate that question form indicates domain epistemology, in that the use of a particular form indicates presuppositions about *how* the domain knows. The two dimensions of knowledge domains, ontology and epistemology, are reflected in the knowledge domains' question formulations. The question then arises as to the third dimension, of whether and how the sociological dimension of knowledge domains,

defined by Hjørland and Hartel (2003b) as being “about groups of people working with some objects by applying some approaches,” is reflected in the domains’ question formulations.

The answer to this question is not found in the data collected and analyzed for the current study. The sociological dimension of a knowledge domain, when considered as a dimension apart from the ontological or epistemological, refers primarily to the social infrastructure of the knowledge domain: the intellectual influence of mentors, colleagues, institutional training; the existence of funding and other types of support for certain types of research; the norms and mandates of publication; the realities of career development and advancement. These sociological dimensions are not well captured by the knowledge products of inquiry, but are better studied by ethnographic study of question formation. Methodologically, investigating how the question manifests the sociological dimension of the domain is likewise not evidenced in the knowledge products of inquiry (dissertation abstracts) that serve as the main data for the current analysis.

One possible explanation of the manner in which the sociological dimension may manifest in domains’ questions will be suggested as a topic for future research. The social dimension of the knowledge domain may determine, of all of the possible questions that could be asked according to the content and form requirements of the domain, which are “relevant” to the domain and thus “worthy” of asking. A study of what factors determine the “relevance” of questions is likely to reveal the influence of the social forces listed above and more: funding and resource availability; the influence of dissertation chairs, advisors, and other mentors; consensus about the “hot” topics in the domain; convergence with other domain developments such as theoretical or

methodological trends, or technological advances; and the formal and informal associations between researchers within and across knowledge domains. Socially relevant questions, thus described, may function as a filter for the broader set of ontologically and epistemologically relevant questions in any given domain.

## **8.5 Summary of findings and conclusion**

Research questions 4b and 5b ask, what information do question content and form convey about the assumptions that precede the question? The analysis of neuroscience, literature, and computer engineering question formulations about “memory” show that question content conveys ontological commitments to the kinds of entities that exist in the domain’s reality, their substance, features, and relations. Question content indicates domains’ ontologies. Furthermore, a comparison of the three domain’s five question forms presuppose epistemological beliefs about what constitutes knowledge, how it is derived, its sources and limits, the nature of the relationship between knower and known, and the nature of evidence and justification. Question form indicates domains’ epistemologies. Together, question content and form characterize distinct types of inquiry into “memory” – descriptive, determinative, prescriptive, creative, and critical – that produce knowledge of different facets of “memory” – its mechanisms and properties, uses, relations to other phenomena, and its very nature.

While not directly investigated in the current study, it is further proposed that question relevance reveals the social dimension of the domain. What is meant by this proposition is that determinations of which questions, of all those that are ontologically and epistemologically correct, are most relevant to the domain and thus pursued by

researchers, are subject to the structures, resources, and influences of the knowledge domain as a social unit of knowledge production.

The question paradox states that in order to ask what one does not know, one already has to know (Flammer, 1981). In the context of knowledge domains and the comparative domain analysis of questions, the paradox is resolved: in order to ask a question, one already has to know *what* to ask (question content) and *how* to ask it (question form). Knowing what the indeterminate situations are and how to structure inquiry relative to the topic infers that one also knows what will resolve the indeterminacy and how produce that knowledge. Knowing what and how to ask also presumes that one knows the tacit ontological and epistemological assumptions that constrain and enable the inquiry. In a sense, knowing what and how to ask is a microcosm of domain members' competence in inquiry, an expression of members' knowledge of and ability to work within the domain's assumptions to produce relevant domain knowledge. While the comparative ontological and epistemological analyses offered in this chapter are basic and may suffer from the broad differences between three such contrasting domains, they serve as evidence for the ability of questions to convey information about the knowledge domain context, namely the tacit ontological and epistemological assumptions of the domain that serve as the context for inquiry and the production of knowledge.

Questions convey information as well as request it (Kearsley, 1976) – about the answers that follow and the assumptions that precede the questions (Dillon, 1990). The current investigation demonstrates that questions are social epistemological tools of inquiry, wielded in relation to domains as units of and contexts for the production of

knowledge. The precise relationship between question elements and the ontological, epistemological, and social dimensions of knowledge domains is further explored in Chapter Nine: A social epistemological model of domains' question formulations.

## **CHAPTER 9: A SOCIAL EPISTEMOLOGICAL MODEL OF DOMAINS' QUESTION FORMULATIONS**

### **9.1 Questions as tools of inquiry**

This dissertation proposes a social epistemological conception of questions as epistemic devices, tools used to transform indeterminate situations into determinate ones in relation to knowledge domains as social units of knowledge production. A comparative analysis of three domains' questions formulations provides a picture of the way in which questions are utilized to express the indeterminate situations that motivate inquiry and to convey the epistemic structures for resolving the indeterminacies. Questions are tools of inquiry and as such, they indicate in their formulations what they are meant to do. This chapter reflects on the status of questions as tools, objects designed to organize inquiry towards the production of domain-justified knowledge. Based on the empirical findings about the question formulations of the neuroscience, literature, and computer engineering domains' dissertation research on the topic of "memory," a theoretical model is developed of the manner in which questions are designed to convey information – about the answers that follow and assumptions that precede – to organize inquiry in a manner that adheres to norms and practices of the domain asking the question. The empirical findings, which form the basis of the theoretical model, are here summarized in relation to the idea of the question as a tool of domain inquiry, followed by the presentation of the model and discussion of its implications for theory and practice.

## 9.2 Summary of empirical findings

A question analysis was conducted on the knowledge products of three knowledge domains' research on a common topic – neuroscience, literature, and computer engineering dissertations abstracts and full-text dissertations on “memory” – in order to identify, categorize, and compare the question formulations in each domain and to consider what information they convey about the answers that follow and assumptions that precede the questions. The question formulation categories that comprise the question profiles of each domain demonstrate that questions take different shapes between and even within the domains, such that the question formulations function to convey information about the expectations for an answer and the domain assumptions upon which the question and answer are produced.

**9.2.1 Neuroscience.** Of the three domains, the question profile of neuroscience contains the most and most diverse question formulation categories. Table 62 shows that the neuroscience question formulations can be divided into three distinct categories in accordance to question content and form.

<i>Q-A content</i>	<i>Ontological commitments</i>	<i>Q-A form</i>	<i>Epistemological presuppositions</i>
3. Substance/definition – Neural correlates of memory 4. Character/description – Neural mechanisms of memory; 4. Character/description – Role of <i>X</i> in memory	<ul style="list-style-type: none"> <li>• Substance: memory as material process</li> <li>• Features: Plasticity</li> <li>• Structure: Multiple and localized</li> <li>• Relations: Conditional or causal</li> <li>• Conditions of existence: Neural function</li> </ul>	Research question-finding	<ul style="list-style-type: none"> <li>• Way of “knowing”: scientific observation</li> <li>• Knower and known: objective relation</li> <li>• Evidence: Experimental results</li> <li>• Justification: Internal logic of inquiry; external state of domain knowledge</li> </ul>
6. Rationale/explication – memory models or instruments		Goal-tool	<ul style="list-style-type: none"> <li>• Way of “knowing”: development of tools</li> <li>• Knower and known: objective relation</li> <li>• Evidence: design of tool</li> <li>• Justification: Efficacy in attaining goal</li> </ul>

12. Conditionality – Y and memory; 13. Biconditionality – Z and memory		Hypothesis-confirmation /disconfirmation	<ul style="list-style-type: none"> <li>• Way of “knowing”: Experimental testing</li> <li>• Knower and known: objective relation</li> <li>• Evidence: empirical results</li> </ul> Justification: reliability and validity of experiments
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**Table 62. Summary of empirical findings, neuroscience**

The first type of question formulation, asking *research questions* about the *neural correlates, neural mechanisms, and role of X* (various anatomical and neuronal structures) *in memory*, coalesce around several indeterminate situations in the domain. They can be characterized by the broad questions: what are the different types of memory? Where are they located? How does memory work, at the neural level? These question formulations accompany descriptive inquiry, in which scientific experimentation serves to establish what constitutes an observation of memory’s neurobiological occurrence in the human brain. The first category of question formulations indicates that the answers should resolve the indeterminate situations identified in the question content, and that the answer should take the form of a finding that extends the boundary of what is known about memory in the domain. The finding is justified based on the internal logic governing the design of the experimental studies, as well as relative to whether the answer furthers the state of current domain knowledge.

The second category of questions formulates *goals* related to *memory models and instruments*. These inquiries confront the indeterminate situations related to the tools for observing memory, asking, why or how should certain tools be used to observe and measure memory? The prescriptive style of inquiry of these questions seek to resolve existing epistemic obstacles to the study or clinical treatment of memory through the design and validation of new *tools*, which are evaluated according to the efficacy with

which they meet the goal. The third category of neuroscience inquiry formulates *hypotheses* about *Y and memory* (*Y = diseases and disorders, traumatic brain injury, age, and individual differences*) or *memory and Z* (*Z = cognitive interventions, drugs, mode of presentation, stress*). The question formulations indicate that their answers must resolve epistemic conflicts about whether relations between memory and phenomena of impairment and enhancement can be proven to exist. These determinative inquiries ask, what are the conditions that impair or break memory, and can memory be fixed or enhanced? The experimental results are judged according to the reliability and validity of the experiments that produced them.

The three neuroscience question categories share ontological beliefs about memory: that it is a material process that exhibits plasticity; that there are multiple memory systems that are localized to particularly brain regions; that it requires neural functioning to exist. That the three types of question formulations share common ontological commitments suggests that the ontological dimension is the commonality that binds the sample together as neuroscientific research. What differentiates them are the epistemological presuppositions of the different question and answer forms, the epistemic structures within which each of the three groups resolves the indeterminate situations that characterize them. Though they share a common ontological reality, the three areas of research differ according to the *how* of inquiry: the ways of “knowing,” sources of evidence, and criteria for justification of knowledge. This confirms Hjørland and Hartel’s (2003b) assertion that knowledge domains are primarily ontologically defined.

**9.2.2 Literature.** The question formulations found in the literature sample divide sharply into two categories: the critical inquiry of literary criticism and the creative inquiry of creative writing (Table 63).

<i>Q-A content</i>	<i>Ontological commitments</i>	<i>Q-A form</i>	<i>Epistemological presuppositions</i>
6. Rationale/explication – Literary uses of memory; 6. Rationale/explication – Literary construction of memory	<ul style="list-style-type: none"> <li>• Substance: memory as abstract act</li> <li>• Features: Subjectivity; malleability</li> <li>• Conditions of existence: Agent</li> </ul>	Topic-thesis	<ul style="list-style-type: none"> <li>• Way of “knowing”: argumentation</li> <li>• Knower and known: subjective relation</li> <li>• Evidence: critical analyses of literary texts</li> <li>• Justification: Strength of argument</li> </ul>
15. Acquaintance – Nature of M		Theme-interpretation	<ul style="list-style-type: none"> <li>• Way of “knowing”: direct encounter</li> <li>• Knower and known: subjective relation</li> <li>• Evidence: literary texts</li> <li>• Justification: Quality of experience</li> </ul>

**Table 63. Summary of empirical findings, literature**

The first category formulates questions in the form of *topics* having to do with the indeterminate situations related to the *literary uses of memory* and *literary construction of memory*. They ask, to what end do literary texts wield memory and how is it the end accomplished in the text? These are the indeterminate situations that this type of question formulation requires the answer to resolve. Critical inquiries produce arguments about the text or group of texts, built as a series of claims or premises that conclude in the answer form of a *thesis* statement. The thesis is justified as having resolved the indeterminate situation based on the soundness and strength of argument that the texts support the premises and conclusion.

A second small subset formulates questions as literary *themes* that characterize the indeterminate situation as being about the *nature of memory*. Themes are resolved in creative inquiries by the production of *interpretations* of what the literary texts have to

say about the nature of memory, as produced by the readers' direct encounters with memory in the texts. The interpretation is justified as knowledge according to the quality of the readers' direct experiences of memory in the text, such that the deeper or more engaged a readers' experience, the greater weight that is given to their interpretation as a resolution of the thematic indeterminate situation.

**9.2.3 Computer engineering.** The question formulations in computer engineering are variants of a singular focus: the optimization of the computer memory system (Table 64).

<i>Q-A content</i>	<i>Ontological commitments</i>	<i>Q-A form</i>	<i>Epistemological presuppositions</i>
6. Rationale/explication – M optimization	<ul style="list-style-type: none"> <li>• Substance: Abstract process and material object</li> <li>• Features: Limits (speed vs. capacity)</li> <li>• Structure: hierarchical</li> <li>• Conditions of existence: Hardware and software</li> </ul>	Goal-tool	<ul style="list-style-type: none"> <li>• Way of “knowing”: development of tools</li> <li>• Knower and known: objective relation</li> <li>• Evidence: Design of tool</li> <li>• Justification: Efficacy in attaining goal</li> </ul>

**Table 64. Summary of empirical findings, computer engineering**

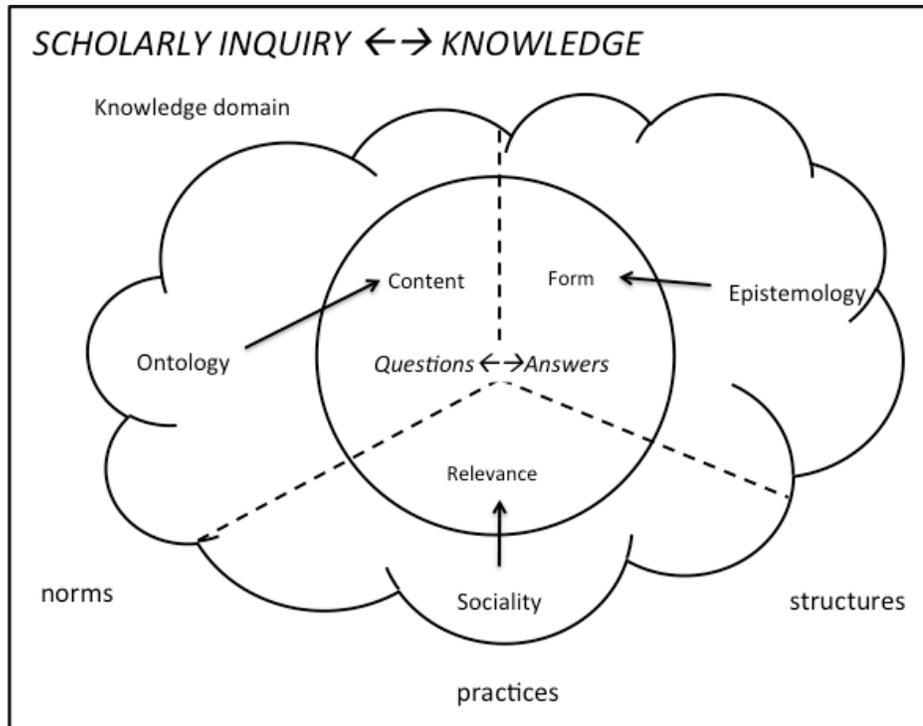
Computer engineering's question formulations are presented as *goals* related to *memory optimization*. The indeterminate situation is singular: how can memory be optimized for system performance? Every question formulation in the sample is a variation of this question, even as each differs according to the established parameters of the use case, the level of the memory hierarchy being addressed, and the approach being taken. Inherent in these questions is the existence of epistemic obstacles to the optimization of memory. The specific *goals* formulated in relation to this broad question are resolved by the development of a *tool* that functions to overcome the obstacle, whether in the form of a memory system overhaul, novel approaches to structuring the memory hierarchy, models for integrating new memory technologies, or even the redesign of hardware components

like memory circuits. The tool that is developed and implemented is evaluated according to its efficacy in overcoming the epistemic obstacle and attaining the goal.

**9.2.4 Summary.** The question profiles of the three domains are produced by the categorization of their contents (the expressions of the indeterminate situations motivating inquiry), and forms (the epistemic structure for resolving the indeterminate situations). By locating a question formulation within a question category, it is evident that the “shape” of the category – its characterization of question content and form – functions to “shape” the content of the answer and the manner of its production. Thus the question formulations function to organize inquiry according to the assumptions of the knowledge domain or subdomain of origin.

### **9.3 A social epistemological model of domains’ question formulations**

The empirical findings emerging from the research questions provide the basis for the theoretical model in Figure 4. The following propositions further explain the terms and concepts employed in the model and their relations. Since the empirical findings are about the question formulations present in scholarly domains’ questions, the model specifies that its context is the realm of scholarly inquiry and knowledge, though it is surmised that non-scholarly – “everyday” or “common sense” – domains of inquiry may adhere to the same model.



**Figure 4. Social epistemological model of domains' question formulations**

**Proposition 1.1. Inquiry produces knowledge; knowledge is defined in relation to the inquiry.** Inquiry is defined as the directed or controlled transformation of an indeterminate situation into a determinate one (Dewey, 1938), which is conducted through the asking and answering of questions, in accordance with the norms, practices, and structures of the knowledge domain or domains of origin. The result of competent inquiry is the production of knowledge (Dewey, 1938). Inquiry and knowledge are thus in a complementary relationship: inquiry produces knowledge, and knowledge exists only in relation to the inquiry. As knowledge does not exist objectively but in relation to an inquiry, it requires an inquirer or knower, whether the knower is an individual or collective knower. The knowledge that results from inquiry may be externalized in the

form of knowledge products, such as dissertations, abstracts, and articles in the scholarly context, or may remain internal to the questioner.

**Proposition 1.2. Inquiry and the production of knowledge are carried out in the context of knowledge domains.** The defining context of knowledge and inquiry is the knowledge domain. Whereas the terms “knowledge” and “inquiry” are used in the cognitive paradigm to refer to individuals and their individual investigations, here the terms are understood as reflecting the social epistemological context of the knowledge domain. The components of inquiry identified in Chapter Seven: Question forms, in their relation to one another and particularly to the components of the *question* and *answer*, reveal the epistemic structure of inquiry. This structure begins and ends with the current knowledge that the domain possesses about “memory.” In the neuroscience and computer engineering abstracts, the questions are posed relative to what is already known in the domain, as when *research questions* and *hypotheses* are formulated relative to epistemic gaps in the *state of domain knowledge*, or *goals* are formulated to overcome epistemic obstacles stated as domain-level *problems*. Inquiry is always framed relative to the existing knowledge about “memory” in the knowledge domain, as is reflected in the question content as an expression of the indeterminate situation regarding “memory” in the domain. Conversely, “knowledge” is the sum of all that is known about the objects or phenomena in the world as collectively possessed, in the sense of being produced, justified, and communicated, by the entire body of the knowledge domain. Inquiry produces knowledge, and knowledge begets more inquiry.

As a context for inquiry, knowledge domains have definable borders, reflecting that there are social norms for the production of knowledge. However, the boundaries are

nebulous, as knowledge domains are in a constant state of growth and change, due to the absorption of new knowledge or other influences outside the domain.

**Proposition 2.1. Questions solicit answers; answers are defined by the questions.** Much like knowledge and inquiry, questions and answers are complementary, two sides of the same phenomenon. Questions and answers are formulated in relation to each other, so much so that the question is most precisely formulated only in the full knowledge of the answer. For this reason, the knowledge products of inquiry, such as the dissertation abstracts studied in this investigation, are an especially apt source of data for the study of questions and answers: they present the questions and answers in their final form rather than in the midst of development. The empirical findings confirm Dillon's (1990) assertion that questions convey information about the answers that follow. The content of the question identifies the indeterminate epistemic situation that needs resolution; the answer is that which resolves the indeterminate situation. Likewise, the form of the question indicates the manner in which the inquiry should be conducted in order to justify belief in the resulting knowledge, including the form that the answer should take and the criteria by which it should be evaluated as justified belief.

**Proposition 2.2. Questions and answers are formulated in the context of a knowledge domain.** Questions and answers are not idiosyncratic in their formulations, but are formulated within the perspective of the knowledge domain and according to its social epistemological norms and practices. The implication of this proposition is that knowledge domains can be characterized by the questions that they ask and the answers that they produce. In this manner, domains can be described by their question profiles, which can serve as concise representations of knowledge domains. This proposition

emerges from the central empirical finding of the comparative question analysis: that neuroscience, literature, and computer engineering have distinct question profiles, and that the different categories of question formulations require answers to be produced and formulated accordingly (Tables 62-4).

There is no such thing as a question formulated outside of the context of knowledge domains, only one that asks or answers poorly according to domain standards. While questions and answers are complementary entities, it is possible to properly formulate a question for the domain but still arrive at an invalid answer due to the improper handling of the inquiry. However, it is unlikely, if not impossible, that a domain-appropriate answer would result from an improperly formulated question. Questions may be formulated between two or more knowledge domains, reflecting a multi- or inter- or cross-disciplinary approach. These sorts of questions may eventually differentiate enough from the existing domains of reference to form a new knowledge domain, particularly when aided by technologies that enable new categories of questions to be formulated. This is seen in the split between first order and third order question formulations in neuroscience. Third order questions, extending from the traditional psychological tradition, produce determinative inquiry through *confirming or disconfirming hypotheses* about the conditional or biconditional relations between memory and impairing or enhancing phenomena. According to an interview with one author (N29), the growth in widespread accessibility to brain imaging technologies is credited with the current flourishing of modern neuroscience as its own discipline apart from psychology, as is represented by the first order questions posing *research questions*

that produce descriptive *findings* about the *neural correlates*, *neural mechanisms*, and *role of X* (anatomical or neuronal structures) *in memory*.

**Proposition 3. Question content reflects domain ontology.** Domains are described as having three dimensions: ontological, epistemological, and social (Hjørland & Hartel, 2003b). The dimensions describe the types of assumptions that structure the practice of inquiry within the domain. The comparative question analysis finds that these assumptions are tacitly manifest in the domain's question formulations. Comparative analysis of the *content* of question formulations, comprised of a *query* posed about a *subject*, reveals ontological assumptions about the substance, features, structures, relations, and conditions of existence for "memory." For instance, literature inquiries posing queries of *rationale/explication* about the *literary uses of memory*, asking how literary texts function to *negotiate trauma* or *challenge historical memory*, assume that memory is an abstract act, subjectively held, and in the end, malleable. Implicit in the query-subject pairing are ontological commitments to "memory" as an object of inquiry and the world that it inhabits. The implication of this proposition is that if presented with a list of a domain's question formulations, one could infer the ontological commitments of the domain by identifying the subjects and queries that comprise the question content, particularly if viewed in contrast to another domain.

**Proposition 4. Question form reflects domain epistemology.** Whereas domain ontology reveals what can be known in the domain, epistemology tells us how it can be known. Domain epistemology constricts the forms in which question content is presented in a manner that structures the components and relations of inquiry. For instance, a *hypothesis* demands *confirmation or disconfirmation* and orients the inquiry

according to the rigor of experimental science, while a *goal* requires a *tool or instrument* to be designed and evaluated in order to solve a practical problem. The question form is indicative of the ways of knowing that are appropriate in the domain, which in turn indicates the appropriate form of the answer and the criteria for evaluating the answer as justified belief, by domain standards. Domain epistemology determines the epistemic form of the question, which subsequently organizes inquiry according to the epistemological presuppositions of the question form. Conversely, identifying the epistemic question forms utilized by the domain gives a broad indication of the domain's epistemological orientations.

**Proposition 5. Question relevance reflects domain sociality.** This proposition is the sole proposition not based directly on the empirical findings of the comparative question analysis, but is inferentially determined and proposed for future study. In the broadest sense, any question that is formulated in accordance with the ontological and epistemological assumptions of the knowledge domain is a domain-relevant question, and any answer produced accordingly is a relevant answer. In a narrower sense, the relevance of questions and answers, the determination of whether the question is “worth” asking and the answer “worth” knowing as judged by the domain, are a product of the domain's social dimension or social values. Relevance, in this narrower sense, is determined by a confluence of dynamic social forces such as the influence of advisors and mentors, funding and resource availability, systems of reward including tenure requirements, awards, conference and publication guidelines, and other manifestations of the domain's social infrastructure. Some aspects of the social dimension's influence on question relevance may be explicit (publication or funding guidelines) while others are implicit

(departmental culture); some are formal (doctorate requirements) while others are informal (influence of colleagues). The social dimension of the domain ultimately judges some possible questions as more relevant than others.

These propositions support the conception of questions as domain tools for organizing inquiry according to the ontological, epistemological, and social assumptions of the knowledge domain. In its current state, the model is a static picture of the question formulations of a single knowledge domain engaged in inquiry and the production of knowledge. Additional analyses of domains, both cross-domain and topical comparisons and historical studies, will provide more data for the potential further development of the model, particularly in regards to the formulation of questions between domains and the evolution of domains over time. Other dimensions of questions may also emerge as indicative of domain assumptions, requiring their addition to the model. For instance, the *function* of questions may be indicative of a knowledge domain's axiological assumptions, related to the value of knowledge and its proper use. With further development and testing, a social theory of questions may emerge, offering a social epistemologically informed addition to existing models and theories of information behavior.

#### **9.4 Implications of the model**

The proposed model recasts the question as a social epistemological entity and tool of inquiry. It views the opacity of questions as informative – of the knowledge domain context and what that implies about the nature of inquiry and the production of knowledge – rather than problematic. In resolving the question paradox, the social epistemological conception of the question reasserts the centrality of the question in the

following bodies of theories and practices seeking to explain humans' interactions with information in the context of inquiry and the production of knowledge.

**9.4.1 Domain analysis.** The question analysis of Chapters Five, Six, and Seven demonstrate that domains' questions communicate the indeterminate epistemic situations of the domain regarding memory and the epistemic structures by which knowledge can be produced to resolve the indeterminacy. One of the implications of this finding is that producing a question profile can be considered as a tool or interpretive context for many of the eleven approaches suggested by Hjørland (2002b), including approaches such as producing literature guides and subject gateways, producing special classifications, empirical studies, bibliometrical studies, historical studies, and epistemological and critical studies. For instance, the production of literature guides and subject gateways can be initially organized according to the categories of question formulations that constitute the question profile. Question formulations may then be translated into domain-specific language, as well as restructured or reorganized according to the discretion of the information specialist as suitable to the level of expertise and purposes of the target audience. Here we see the distinct value of the information specialist as separate from the subject specialist, as a translator that goes between the subject content as represented in the information resources, the subset of the domain audience as the user group (undergraduate students, graduate students, etc.), and the knowledge structures of the domain context, in order to provide access to the domain universe of documents.

As demonstrated in the question analysis in previous chapters, the process of identifying questions and classifying them according to content and form groups of like research with like, providing descriptive characterizations that can serve as the basis of

discussions of identifying domain boundaries and defining the central concerns of the domain versus those that are peripheral. The process and results of analysis can serve as a reflexive exercise, a method for considering evaluating the state of knowledge in the domain and whether and how the domain's own image of its knowledge production measures up to the picture produced by a question analysis of its research, with the representativeness of the sample guiding the interpretation of the results. If the sample is taken to be representative of the domain's production at a given point in time, the resultant question profile is a current snapshot of domain knowledge. A sample of research across time will show the evolution of questions, producing a sort of "history of questions" of the knowledge domain. The question profile can serve as a visualization technique for representing the questions asked and knowledge produced by a domain or domains, a "question map" of the domain. Within a domain, the same technique can be used to characterize and compare research-producing bodies such as journals, publishers, research labs or centers, graduate schools, doctoral programs, etc.

All of these reflexive exercises also apply to topical research, which is identical in form to domain research, but orthogonal to it in terms of content. The current investigation is a brief and limited example of topical question analysis, producing an overall question profile of "memory" as pursued by three domains. In terms of within domain topics, reviews of research such as those published in the Annual Review of Information Science and Technology (ARIST) annual publication series from 1966 to 2011 could be produced and organized by applying this question analytic method to the review of relevant literature. In fact, question analysis may be a productive technique for organizing literature reviews of any scope and size, from small group of articles, to the

reviews of subfields of research, to the characterization of entire knowledge domains or multiple domains.

**9.4.2 Document relevance.** The orientation towards domains' questions that is suggested by a social epistemological model of domains' question formulations offers a contextual grounding for the study of what constitutes a relevant document in any given knowledge domain: documents provide *evidence for the knowledge claims* being produced *in response to the questions being asked*. The primary relevance criterion is epistemic and relative to the question. This explains how two groups with contrasting knowledge claims can call upon the same document as evidence to support their claims: the two groups are asking different questions and construct the epistemic relevance of the same document differently. Relevance is recast as a relation primarily between documents and the domain-based questions that they are being applied toward, and only within that primary context, as between individual questioners and documents. By implication, the production of indexing systems for documents can be guided by the question, "what questions does this document pertain to?" rather than simply, "what is this document about?" This approach highlights the inherent contextual nature of questions and their capacity for revealing the social epistemological nature of inquiry as aligned with what Hjørland (2001) identifies as the request-oriented, rather than document-oriented, view of document "aboutness."

**9.4.3 Question negotiation.** In addition to domain analysis, the proposed social epistemological model of domains' question formulations resolves the question paradox-related unease of existing theories of information behavior by reframing the question as seeking to participate in a knowledge domain rather than as reflecting the questioner's

internal state of information need. A detailed example will demonstrate this process. Consider Taylor's (1968) model of question negotiation, in which the information intermediary is called upon to negotiate the inquirer's question, from the question representing the "compromised need," stated in terms of the inquirer's expectations of the information system, back towards the "visceral need," which is the "actual, but unexpressed need for information" (p. 182). The paradox of the question is present in the very notion of a "visceral need" and the impossible imperative for the information intermediary to negotiate back to the inquirer's "visceral need," for how would either of them know whether and when they have attained an acceptable answer to a question that asks about precisely that which is not known?

What ends in the paradox of the question in the cognitive model of question negotiation becomes informative in the social epistemological model. In the social epistemological model of domains' question formulations, Taylor's (1968) four stages of question negotiation may be reframed towards the knowledge domain context as follows:

1. The *visceral question* arises in the inquirer as an inexpressible sense of an indeterminate epistemic situation in the domain of participation.
2. The *conscious question* is the within-brain expression of the domain's indeterminate epistemic situation.
3. The *formalized question* is the formal statement of the domain's indeterminate epistemic situation.
4. The *compromised question* is the domain's question as presented to the information system.

In the social epistemological model, question negotiation entails the identification of the knowledge domain in which the questioner is seeking to participate, proceeding to translation of the individual question into domain terms. Once the domain has been identified, the cognitive idiosyncrasies or situational specificity of the questioner can be taken into consideration in relation to the domain. The struggle of both the individual questioner to formulate a question and the information intermediary to understand the question is unlocked by a re-orientation to the common context of the knowledge domain rather than the disconnect between the questioner's and intermediary's internal cognitive states. Domain-based question negotiation differs from the current strategies of question negotiation in that the negotiation is not towards the individual's visceral question, but towards the identification of the knowledge domain and its norms of question formulation.

Taylor (1968) finds that information intermediaries solicit five general types of information in an attempt to negotiate the question: (1) determination of subject; (2) objective and motivation; (3) personal characteristics of inquirer; (4) relationship of inquiry description to file organization; and (5) by soliciting information in the general categories listed here, anticipated or acceptable answers. The social epistemological reorientation of question negotiation suggests that the most important general category, even before or simultaneous with determination of subject, is the determination of the knowledge domain. Identification of the knowledge domain immediately restricts the determination of subject (and query, and question form) to the normative domain categories of question formulations. After this determination, the individual inquirer's objective and motivation and personal characteristics can be considered, and finally, the question can be adapted to the information system requirements.

**9.4.4 Information retrieval design.** The following example demonstrates the way in which or how social epistemologically informed question negotiation may be translated into practical guidelines for the design of information retrieval systems. Imagine that a questioner approaches an information intermediary, whether reference librarian, search engine, or a database search function with a question about “vaccines and autism.” In a poorly negotiated encounter, the information intermediary will simply present the questioner with a de-contextualized series of documents that are topically related to vaccines and autism. This is the typical result of a keyword search in a search engine or digital library: a series of results, ordered by relevance as determined by the search engine’s algorithm, but giving no indication of the perspectives (knowledge domains) from which the results emerge. Does the document represent the growing anti-vaccination movement’s perspective? The perspective of the corporate lobby? Or a public health perspective? In a well-negotiated encounter, the intermediary will determine (1) that the questioner is seeking documents relevant to a specific perspective, or (2) that that the questioner wants to learn about all the perspectives. In either case, even the acknowledgment of different perspectives – the epistemological dimension – is more than is indicated by a typical de-contextualized list of results.

Information retrieval that is based on the domain-based approach to question negotiation would present the questioner with a series of statements identifying the assumptions of different knowledge domains’ related to the topic, offering a contextualized and easily comprehensible way of indicating which knowledge domain the questioner is most closely aligned with. For instance, the question “Should I vaccinate

my child?” could return the following follow-up statements, one or more of which can be chosen to refine the question:

- I want to know what the medical research says about the benefits and potential risks of vaccination.
- I am worried about the potential danger of vaccinations to my child’s health.
- I worry about the deterioration of herd immunity.
- I don’t believe that the government should interfere with my religious or personal rights.

The following question formulations could then be offered as domain-based variations of the stated question, as they emerge from the sets of assumptions identified:

- What do medical experts say about whether I should vaccinate my child?
- What are the chances that my child will get autism (or other potentially harmful effects to my child) if I vaccinate them?
- What are the potential harmful effects to society if individual parents opt out of vaccinating their children?
- What right do school districts and the government have to determine whether parents have to vaccinate their children?

By this method, the questioner gains a sense of the different formulations that their question could take, in a manner that does not require them to be able to identify the knowledge domain or domains with which they are most closely aligned but simply requires them to recognize which version or versions of the question are most akin to

what they are asking<sup>10</sup>. The resulting relevant documents will then present their information in reference to the underlying knowledge domain assumptions.

The social epistemological approach to question negotiation suggests that an initial question should be negotiated by producing domain-based variants of the question that locate the formulation in relation to specific knowledge domains and their ontological and epistemological assumptions. Search results in the Google search engine have gone in this direction, offering among its early results, a box called “People also ask,” which offers the option to preview the search results for other questions that are presumably related to the initial question. A search for “should I vaccinate my baby” in Google returns the following related questions in the “People also ask” box:

- When do babies get their shots?
- Are vaccinations mandatory in the US?

While the precise method for producing these related questions is unknown, our approach suggests that question analyses of knowledge domains can inform the selection and formulation of the related questions according to a diversity of domain approaches to the topic, rather than or in addition to related questions. The domain-based questions reformulations listed above, which are variants of the question based on the epistemological and ontological assumptions of different domains (medical, parenting, public health, governmental domains) are more aptly reformulations than related questions, perhaps best described as “Did you mean...” rather than “People also ask.”

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<sup>10</sup> Alternately, the first set of statements designed to draw out inquirers’ assumptions may be skipped entirely, with the inquirers directly shown the epistemically informed question formulations related to the initial keyword search.

The domain-based approach offers several advantages over the existing practice of question negotiation. First, having the option of choosing among various question formulations of the topic provides a method for determining the knowledge domain of inquiry without the inquirer having to directly state it. Second, it makes visible the process of negotiation, which is often done intuitively or invisibly by the information intermediary, with little revealed by the intermediary between receiving the stated question and providing search results. The question formulations (one could think of them as variants of the stated question) are more straightforward for the information intermediary to present and easier for the questioner to comprehend than a series of abstruse follow-up questions or prompts. Finally, this method inculcates a greater level of neutrality into intermediation that, whether human or digital, largely masks the values and biases that influence the question negotiation and search results, by making visible the possible domain formulations of the questions and the underlying assumptions. Overall, the focus of question negotiation is shifted towards a coordinated identification of the proper domain formulation, rather than attempting to translate the visceral question into system terms, through the lens of the intermediary.

**Inquiry-based learning.** Emerging from the constructivist theories of learning by Piaget, Dewey, Vygotsky, and others who consider the learner an active, meaning-making subject rather than a passive recipient of information, inquiry-based learning is a pedagogical method that is centered around the asking and answering of learner-generated questions. Inquiry-based learning is built upon the assumption that the most effective way to learn is by asking and answering questions, rather than simply memorizing content. Armed with question profiles of knowledge domains, teachers can

guide students more clearly as to how to ask domain-relevant questions, how to produce domain-relevant answers, and upon what assumptions the question and answer formulations rest. Document relevance is then understood in terms of its relation to the nature of inquiry in the domain. In this manner, learning to ask the “right” sorts of questions is not simply the first stage of learning how to be a historian, chemist, or engineer, but encapsulates the entirety of domain approach to the production of knowledge.

Several categories of research that can be seen as falling under the broad umbrella of inquiry-based learning: discipline-based inquiry, project-based inquiry, problem-based learning, challenge-based learning, and inquiry-based teaching (Friesen & Scott, 2013). The social epistemological model of domains’ question formulations is reflected in these research categories, which, apart from their differing emphases on the learner or teacher, are all variations of the epistemic question forms identified in our question analysis. Discipline-based inquiry and inquiry-based teaching encompass modes of inquiry and knowledge production across the humanities, social sciences, and natural sciences, while project-based inquiry, problem-based learning, and challenge-based learning are all likely variant formulations of the *goal-tool* mode of inquiry identified in our analysis, reflecting the more frequent use of inquiry-based learning in domains engaging in prescriptive inquiry. Our analysis shows that the literature domain is also engaged in inquiry, though of a less obvious sort than neuroscience and computer engineering, and that literature students can also benefit from inquiry-based learning that gives them the experience of learning what the literature domain is about by engaging in the practice of literature scholars, whether literary critics or creative fiction writers. At the same time, the

question analysis reveals that critical literary inquiries are structured as an argument relative to a *topic-thesis* framework, which suggests that lectures are a relevant pedagogical technique because they demonstrate how to construct literary arguments. Inquiry-based learning requires knowledge of the nature of inquiry in the domain, which is partially revealed by question analysis of the sort developed in this dissertation.

The social epistemological model of domains' question formulations adds an enriching perspective to Kuhlthau's (2007) Guided Inquiry Design, an approach to designing and implementing inquiry-based learning in schools. The Guided Inquiry Design Framework translates the evidence-based stages of the Information Search Process (ISP) model (2004) into phases of inquiry, which serves as a framework for designing student learning at each phase. As Guided Inquiry is essentially a question- or problem-based method of learning that is domain-based by nature, there is a natural affinity between it and the social epistemological model of domains' question formulations. Table 65 shows how each stage of the ISP and corresponding Guided Inquiry phase can also be paired with the specific stages of question and answer formulation as suggested by the social epistemological model of domains' question formulations.

<i>What students are doing in ISP</i>	<i>Stages of ISP</i>	<i>Phases of guided inquiry</i>	<i>Stages of question formulation</i>
Initiating the research project	Initiation	Open	Familiarization with domain's question formulation categories
Selecting a topic	Selection	Immerse	Selection of domain question category
Exploring information	Exploration	Explore	Exploration of what is known, or current state of knowledge in question category
Formulating a focus	Formulation	Identify	Formulation of precise question, according to content ("known unknown" or indeterminate epistemic situation) and form (logical structure)
Collecting information on focus & seeking meaning	Collection	Gather	Formulation of answer, according to content and form indicated by question
Preparing to present	Presentation	Create and	Presentation of inquiry, according to

		share	domain standards of justified knowledge
Assessing the process	Assessment	Evaluate	Assessment of question and answer formulation in terms of domain criteria for relevant questions and justified knowledge

**Table 65. Stages of question formulation corresponding to Kuhlthau's ISP (2004) and Guided Inquiry Design (2007)**

The stages of question formulation orient the stages of the ISP and phases of Guided Inquiry towards the knowledge domain context. The last column in Table 65 offers specific guidelines for teaching the inquiry process through the lens of domain-based question formulation: from familiarization with the question categories, to selection and exploration of a specific category, to formulation of the question and its answer, and presentation and evaluation of the question according to domain norms of justified knowledge. Orientation towards the existing relevant domain context translates the generalized Guided Inquiry Design phases into actionable and teachable steps.

## 9.5 Conclusion

Questions convey information (Kearsley, 1976) about the domain's expectations that the answer resolves the epistemic indeterminacy expressed in the question content, and that is produced within the epistemic structure indicated by the question form. The elegance and efficiency of communication within a domain dictates that the foundational assumptions of inquiry go unstated; however, their traces are evident in the formulation of the question as a tool for organizing inquiry. A social epistemological model of domains' question formulations resolves the paradox of the question by transforming the impossible imperative for questioners to state precisely what they do not know, into an invitation to the practice of questioning as it already exists within the knowledge domain. The social epistemological model of domains' question formulations proposed in this

chapter emerges from empirical findings of the comparative domain analysis of question formulations about “memory” in neuroscience, literature, and computer engineering dissertations. It reasserts the centrality of the question as a concept for library and information science, but reframes the question as a social epistemological tool, one whose ideal state is relative to the standards of the knowledge domain rather to the “true” representation of the individual’s visceral need. The model simultaneously offers a method for the study and representation of knowledge domains according to their inquiries and the resultant knowledge, and the reframing of individual information behavior as socio-cognitive in nature, as an interplay between individual subjectivity and the social lenses through which individuals construct a shared reality with others.

The model suggests that the tension between the stated question and its implicit context is resolved by making the context explicit, and that the context is the knowledge domain rather than the individual’s “problematic situation” (Wersig, 1979). By reclaiming the direct study of questions but from a social epistemological perspective, the reliability of the question is re-established. Questions convey information about the knowledge domain’s assumptions related to memory as an ontological object of inquiry and the ways of knowing about memory. Their formulation is a means of participating in, or seeking to participate in, a knowledge domain with standards and norms of justified belief. The proposed model is an initial attempt to capture the social epistemological nature of questions by representing the relationship between question structure and its communicative functions in conveying knowledge domains’ assumptions about the nature of inquiry and the production of knowledge.

## CHAPTER 10: CONCLUSION

### 10.1 Overview: The paradoxical nature of questions

This dissertation seeks to re-establish the centrality of the question as a core concept for library and information science (LIS) by re-framing the question as a social epistemological tool of inquiry rather than an indication of an individual's information need. One broad characterization of library and information science as a knowledge domain is that it provides intellectual and physical (including digital) access to the universe of recorded knowledge; it organizes knowledge products in order that they may be "found" when needed, for the production of new knowledge. Library and information science research has long acknowledged the importance of the question in soliciting documents relevant to the formulation of an answer and the difficulty that questioners have in formulating effective questions. Since the cognitive turn in LIS research, questions have been more an obstacle than an effective means to finding relevant documents, unreliable indicators of individuals' "problematic situations" (Wersig, 1979), "information gaps" (Dervin, 1992), and "anomalous states of knowledge" (Belkin, 1980). The essential inability for questioners to formulate effective questions is captured by what Flammer (1981) identifies as the paradoxical nature of the question: that in order to ask a question, the questioner already has to have knowledge – of what can be asked and how to formulate the question in order to solicit an appropriate answer.

By reframing the question from a social epistemological perspective rather than a cognitive one, the solution to the paradox is revealed as present in its very formulation. In order to ask a question, the questioner already has to know *what can be asked and how*

*to formulate the question.* Viewed from a cognitive perspective, this is an impossible demand to make of the questioner. How can one state what one does not know? But once the question is reconceived as a social epistemological object, a tool of knowledge domain-based inquiry, the statement of the question paradox is revealed to reflect Kearsley's (1976) observation that "questions also convey information as well as request it" (p. 355-56), about the indeterminate situations relative to the object of inquiry in the domain and the epistemic structure for resolving the indeterminacy. A social epistemological conception of the question locates individual questioners and their question formulations as relative to the knowledge domains that are the context for inquiry and the social production of knowledge. What one is seeking to know by asking and what one needs to know in order to ask are two different kinds of knowledge (Flammer, 1981). The former is the knowledge that resolves the indeterminate epistemic situation represented by the domain's question, acquired through competent inquiry, while the latter is knowledge of the domain practice of inquiry, which must already be possessed in order to formulate the question.

The overarching question that guided this inquiry is: how do knowledge domains' question formulations about "memory" compare and what do they convey about the answers that follow and the assumptions that precede the questions? Specifically, the research questions ask: what are the contents and forms of domain's question formulations on the topic of "memory," how do they compare, and what information do the comparisons convey about the answers that follow and the assumptions that precede? By these questions, the inquiry is directed towards producing knowledge of how domains differ in terms of *what* they ask about "memory" (question content as expressing

indeterminate situation) and *how* they ask (question form as indicating epistemic structure), and what the comparisons indicate about questions as tools of domain-based inquiry.

The current comparative study of knowledge domains' question formulations about "memory" produces empirical findings on the formulation of questions about "memory" in three domains: neuroscience, literature, and computer engineering. A question profile is constructed for each domain, while comparison between the domains produces a profile of the topic of "memory" as pursued by the three domains. Additionally, comparisons between the domains reveal the the relationship between question formulations and the nature of inquiry in the domain. The major findings are highlighted and synthesized below, providing a picture of the overall significance of this research. The limitations of the study are detailed, particularly as they suggest a future direction for research into the domain-based and question-related criteria for relevant documents.

## **10.2 Identifying the implicit questions that drive inquiry**

Chapter Five details the development of a method for identifying the explicit and implicit questions that motivate and organize inquiry from the knowledge products of inquiry and application of the method in a sample of three domains' dissertation abstracts. Implicit questions are made explicit based on the principle that all knowledge has an indirect question correlate (Hookway, 2008). The precise formulation of the question relies on adaptation of the erotetic definition of questions, as having a communicative function and logical structure, to a domain level of discourse. The neuroscience, literature, and computer engineering dissertations' question formulations about "memory,"

as derived from the dissertation abstracts, are listed in Appendix B. They constitute the main data source for the formation of domains' question profiles. This method establishes a consistent and theoretically informed procedure for determining domains' question formulations about "memory" from the dissertation abstracts, which can be applied to the knowledge products of other domains.

### 10.3 Question profiles

Chapter Six and Chapter Seven categorize the neuroscience, literature, and computer engineering dissertations' question formulations on the topic of "memory" according to content and form, producing three domain profiles and six question categories. The neuroscientific profile of memory-related research, summarized in Table 51, is composed of three question categories: (1) descriptive *research question-finding* inquiries about the *neural correlates of memory*, the *neural mechanisms of memory*, and the *role of X in memory*; (2) prescriptive *goal-tool* inquiries about *memory models or instruments*; and (3) determinative *hypothesis-confirmation/disconfirmation* inquiries about *Y and memory* (where *Y* are impairing phenomena) and *Z and memory* (where *Z* are enhancing phenomena). According to this question profile, neuroscientific research about memory is focused around several central questions:

1. What is the neurological basis of memory – what are its types, where is memory located, and how does it function at the neural level?
2. What tools can be developed to overcome obstacles to the neuroscientific study of memory, as well as its clinical assessment?

3. Do neurological diseases, disorders, age, and traumatic brain injury impair memory? How so? Can cognitive and pharmacological interventions improve or enhance memory? How so?

While the question profile is general, based only on fifty-seven dissertation abstracts over a five-year period, it demonstrates the ability of question analysis to determine the “known unknowns” or indeterminate epistemic situations that motivate neuroscientific inquiries into memory and the epistemic structures within which knowledge is produced. The three question categories reflect neuroscience as a domain that is simultaneously building up pure knowledge of memory at the neural level, but also applying this neuroscientific knowledge to the existing study of the human brain, particularly in regards to the assessment and treatment of the effects of brain disorders or injury on memory performance. The technologically mediated nature of neuroscientific inquiry into the memory is reflected in the inquiries aimed at developing new tools to overcome obstacles to the measurement and modeling of memory. Neuroscience constructs memory as a material process, the knowledge of which is incrementally built through scientific observation and experimentation.

Literature dissertations about memory fall into two question categories (Table 55): (1) critical *topic-thesis* inquiries about memory’s functions and the literary construction by which the functions are accomplished, and (2) creative *theme-interpretation* inquires about the nature of memory. The content and form of these questions describe literary inquiry into memory as asking:

1. How is memory constructed by literary texts and towards what purposes? How do literary texts challenge historical memory? How do they negotiate individual and collective trauma?
2. What is the nature of memory?

The literature domain thus engages in two complementary forms of inquiry and produces two complementary forms of knowledge, critical and creative. In both types of inquiry, memory is constructed as an abstract phenomenon, the object of agents' perceptions of their own individual past or events in the collectively held past, malleable and subject to the purposes of the perceiver as written by the authors of the literary texts.

The computer engineering domains' questions formulations are of a single type: prescriptive *goal-tool* inquiries into the optimization of computer memory systems and technologies (Table 58). The unifying question for the domain is how can computer memory be optimized, according to the systems criteria of the use cases in question? These inquiries produce knowledge of memory as both material object (hardware) and abstract process (software), reflecting the hybrid nature of the domain as a combination of computer science and engineering. The hybrid nature is also reflected in the manner of producing knowledge: through the use of computer simulations to produce abstract representations of material computer systems in order to predict the behavior of potential optimizing solutions.

#### **10.4 Questions and answers**

The question analysis of neuroscience, literature, and computer engineering dissertation research about “memory” supports the proposition that knowledge domains ask different questions and ask them differently. A formal comparative analysis of the

question formulation categories asks, what are the formal similarities that can be observed across the specific instantiations of question content and form and their relation to the answers that follow? First, the content of the question determines what constitutes an answer. If question content is an expression of the domain's indeterminate situation, then the answer must resolve the indeterminacy. Question content is expressed as some type of *query* about a *subject*, for example, a query of *rationale/explication* about the *literary uses of memory*. This indeterminate situation can only be resolved by an explanation about how the literary text uses memory. In this manner, the question content reveals precisely the information that should constitute the content of the answer.

Second, the form in which the question is presented indicates the form in which the answer should be produced and presented. Question form indicates the epistemic structure of competent inquiry towards the production of knowledge, presented as a specific form of answer. Five question forms are identified in the three domains, which, in combination with the corresponding answer form, produce different frameworks for inquiry (Table 66).

	Question-answer form	Type of inquiry
NEURO	Research question-finding	Descriptive
	Hypothesis-confirmation/disconfirmation	Determinative
	Goal-tool	Prescriptive
LIT	Topic-thesis	Critical
	Theme-interpretation	Creative
CE	Goal-tool	Prescriptive

**Table 66. Question-answer forms and inquiry types**

In addition to the question and answer, the abstracts display other components of inquiry, which are defined in relation to the question. Literary questions that present in the form of a *topic* produce knowledge by building an argument, consisting of a series of *premises* and building to a *thesis* statement on the topic. *Theory* and *methodology* shape the

manner in which texts are approached as sources of evidence for the argument. In short, the question form (*topic*) dictates the form of the answer (*thesis*) and the other components of inquiry that shape the manner of its production.

### **10.5 Questions and assumptions**

Dillon (1990) asserts that questioning “entails sentences just before, so to speak, and sentences just after – assumptions and answers” (p. 131). Having analyzed the content and form of questions for what they convey about expected answers in Chapters Six and Seven, Chapter Eight seeks to make visible the unstated assumptions of domains’ question formulations that emerge through comparative analysis of content and form. Domains’ question formulations are shaped by, and thus indicate in their comparative differences, the ontological and epistemological assumptions of the knowledge domain. Question content implies ontological commitments about “memory” as an object of study in the domain (Table 60): its substance, features, structures, relations, and conditions of existence. Three distinct facets of “memory” emerge from the ontological commitments of the domains’ question formulations. Neuroscience constructs memory as a material, biological process, multiple and localized patterns of neural activity that are subject to impairment and enhancement through the mechanism of synaptic plasticity. Literature’s conception of memory assumes that it is an abstract act, a subjective possession of agents of remembrance that is performed in order to challenge history, reclaim one’s identity, or create a new possibility for the future. The computer engineering question formulations are committed to a dualistic view of memory: material and abstract, hardware and software, always advancing but ultimately limited in its balance between capacity and speed.

Likewise, question form reveals epistemological presuppositions about the production of knowledge about “memory” in the three domains (Table 61). The question forms in the three domains reveal five ways of “knowing” about memory, each assuming different relationships between knower and known, sources of evidence, and measures of justification. Neuroscientific inquiry into memory entails three approaches: scientific observation of memory as a neurological phenomenon, experimental testing of the relationship between memory and other phenomena, and the development of tools for the further study of memory and clinical treatment of memory-related problems. The literary ways of “knowing” are complementary: argumentation of how memory functions and what it is used for in literary texts, on the one hand, and direct encounter of memory in literary texts, on the other. Computer engineering question formulations convey that memory is known through the development of tools for its optimal performance.

In terms of the social dimension of knowledge domains, it is proposed that questions formulations can also convey information about the social assumptions of the domain related to relevance, namely what constitutes a relevant question in the domain, and why. Verification of this proposition is not presented in the current empirical study, but is proposed as a future topic for research. In this manner, we find that questions are social epistemological objects, possessing the properties of the knowledge-producing domain that utilizes it.

The empirical findings detail the manner in which the precise question formulations of each domain outline the different approaches to “knowing” or “seeing” “memory,” within and between knowledge domains. The question serves as the linchpin of inquiry, the entity connecting, constraining, and enabling all of the elements of inquiry

within the framework of the knowledge domain's ontological, epistemological, and social assumptions. The reconceptualization of questions as tools of inquiry and question formulations as epistemological objects on which knowledge domains' assumptions are inscribed, is presented in Chapter Nine and visualized in Figure 4 as a social epistemological model of domains' question formulations. The model has implications for areas of LIS research and practice including but not limited to domain analysis, question negotiation, information retrieval, and inquiry-based learning. Most fundamentally, the reconceptualization of questions as inherently social epistemological in nature suggests a similar reframing of relevance as a fundamentally social epistemic phenomenon rather than an individual cognitive one. Armed with a social epistemological model of domains' question formulations, renewed focus can be applied to the notion of relevance as a relation between questions and documents.

## **10.6 The practical utility of a social epistemological model of questions**

The question profiles of neuroscience, literature, and computer engineering dissertation research about "memory" produced in Chapters Six, Seven, and Eight demonstrate the utility of question analysis as a method for characterizing knowledge domains according to what and how they ask. A theoretical model is proposed that relates the categorical aspects of question formulations (content, form, and relevance) to the dimensions of knowledge domains (ontological, epistemological, social) as the context for inquiry and the production of knowledge. The model has particular implications for several areas of LIS professional practice. It suggests that question analysis be added to the stable of methods available for those conducting domain analyses, for the practical sake of those who provide information to specific domains

through the practices of knowledge organization. For the area of information intermediation, the model suggests that question negotiation and information retrieval systems design re-orient themselves towards the existing norms of domains' question formulations rather than seeking to negotiate back towards the "visceral need" (Taylor, 1968) or failing to make visible the assumptions of documents deemed relevant to the stated question.

In the pedagogical realm, the social epistemological model of questions supports inquiry-based learning by providing a characterization of knowledge domains according to what and how they ask, which can serve as guidelines for educators to design curriculum that teaches how to conduct and evaluate research in any given knowledge domain. Ultimately, the understanding of questions developed in this dissertation, as social epistemological tools of inquiry, clarifies the notion of "relevance" as a relation between the document and the question, rather than a determination of the individual information seeker.

### **10.7 Limitations of the study**

Several limitations constrain the interpretation of the current research's findings. The study of knowledge domains' question formulations, as determined from the knowledge products of domain inquiry, reflects several necessary limitations to the scope and nature of the research. The most serious limitation of the study is that the question analysis is built upon the questions that motivate and organize inquiry, but these questions are largely implicit and must be derived from the knowledge products of inquiry. Erotetic theory is utilized to develop a method for identifying the implicit question from the components of inquiry presented in dissertation abstracts in a manner

that is focused on the epistemic function and structure of the question. Based on the study's results, this is deemed an apt method for dealing with the implicit nature of the scholarly question and preferable to ignoring the question altogether, given its importance in determinations of document relevance. The peripheral risk of taking the implicit or tacit question as the direct object of study is that, as an abstract representation of the indeterminate situation motivating inquiry with respect to the domain, the question formulations may favor conceptual purity over empirical reality. Even the primary identification of question formulations is one step abstracted from the data. Once the question formulations are coded, categorized, further analyzed for what they indicate about the domain-relative nature of inquiry, the question has become an even more abstracted representation of the inquiry. Situated as it is in a web of relations to other question formulations in the domain or in other domains of comparison, it is necessary to constantly ask whether the question categories reflect the reality of the domain. This is best accomplished by careful sampling, being attuned to the purpose of the question analysis – it is meant to inform the construction of an index or classification system? For what type of user, and in what context? – and soliciting feedback from subject experts.

The method for determining the implicit questions from the dissertation abstracts produces a static view of domains as represented by their question formulations rather than a dynamic view of the process of question formation; it is a study of domains' questions rather than the processes by which these questions were formed. The research produces a picture of domain norms, rather than any understanding of how and why individual questioners seek to conform to, challenge or defy domain norms of questioning. Brice Heath (1982) and Goody (1978) demonstrate the necessity and power

of ethnographic approaches to reveal the social substrate of questioning, though their foci emphasize the social dimension rather than the epistemological or social epistemological. If the intent is to conduct research into question formation as a social epistemological process, which research could provide valuable insight into the socio-cognitive dimension of questioning, ethnographic methods will have to be employed.

The two main bodies of theories that form the theoretical framework of the research also present some inherent limitations. As a theory and methodology for library and information science, domain analysis is ultimately oriented towards the production and use of documents rather than study of the social epistemological phenomena themselves. A broader sociological approach to the social dimensions of knowledge, such as is suggested by the study of information-related phenomena as social practices (Lloyd, 2010), gets closer to the social foundations of cognition. The current research is limited to the study of the domain, as reflected in their question formulations, without considering the other elements of a “community of practice” (Wenger, 1998) – the community and shared practices that constrain and enable the production of the questions. Ideally, the profiles of knowledge domains that emerge from question analysis should be interpreted in conjunction with approaches more practical, such as empirical user studies and bibliometrics studies, and more theoretical such as epistemological and ethnographic studies of domains’ knowledge practices, to give a full and deep understanding of the knowledge domains.

Ergetic theory (Brožek, 2011) is called upon in order to provide a theoretical conception of the question that can be utilized to identify implicit questions across diverse domains and to formulate them according to the epistemic functions and

structures of the knowledge domain. Lacking the formal training of a philosopher, it is difficult to cast a critical eye on the conceptualization of the question and the finer points of Brožek's (2011) argument of the semantico-pragmatic nature of questions as a class of expressions. As a result, the current use of erotetic theory is admittedly pragmatic in nature, with the main thrust of Brožek's (2011) theoretical conception of questions utilized to our purposes without a deep dialogue with the tradition from which it emerges. This is perhaps a necessary skill for LIS – or “information studies” – researchers, who call upon the theories and methodologies of other disciplines to shed light on the full range of phenomena emerging from human interaction with information. A similar situation is found in other “studies” fields such as gender studies, ethnic studies, environmental studies, American studies, etc. and is justified by the definition of the field as having a topical focus that is best served by multi-disciplinary approaches.

### **10.8 Future research: Question analysis of domains and document relevance**

The theoretical model emerging from this study merits further research in order to further extend and refine its representation of question formulations as domain-based tools of inquiry. As discussed in Chapter Nine, future research may entail the application of question analysis to single domains at one point in time or over a period of time, with an emphasis on different types of domains than those studied in the current research. Alternately, future studies may entail question analysis of a single topic across domains, but with a greater scope and level of detail than was attained in the current study. Both of these methods would serve to test the model's central assumption, of the

social epistemological nature of questions, and to refine the variables and relationships identified in the model's propositions.

The present investigation asks, what kinds of questions does a knowledge domain formulate about a topic? What information do the question formulations convey about the answers that should follow and the assumptions that precede the questions? In addition to further developing the theoretical model of domains' question formulations, future research will revisit the original impetus for the interest in questions as a topic of study for LIS that remained out of the possible scope for the current investigation: their relation to document relevance, or what information questions convey about what constitutes a relevant document and the epistemic criteria for relevance. The interest that LIS takes in questions is, after all, ultimately pragmatic. The ultimate importance of the question is in its ability to convey the requirements for an answer and, subsequently, the criteria for documents relevant to the production of an answer. The question reveals the nature of the entire inquiry, constraining and enabling the production of knowledge by establishing the normative domain standards for the production of knowledge. Having established that questions are tools of domain-based inquiry, additional research will be conducted to explore the relationship between domains' question formulations and the criteria for what constitutes a relevant document. Rather than assume that relevance is a cognitive property of the individual questioner, relevance criteria will be investigated with respect to the epistemic nature of knowledge domains' question formulations. This research serves as the first step towards an overarching goal of examining how relevance should be understood as the relation between the question – in its social epistemological context – and a document.

## **10.9 Conclusion: The informative nature of questions**

Questions are the functional interface of inquiry (Horne, 1983), the tool by which questioners align their thinking, information seeking, and research with the domain standards for knowledge production. A deep understanding of questions is thus of fundamental importance to the design of systems and services that provide access to the organized universe of knowledge, but the utility of the question as a theoretical concept has been stymied by the paradox of the question: that questioners must know enough to ask about what they do not know. This dissertation resolves the question paradox by shifting from a cognitive to a social epistemological approach that understands the question as a tool of inquiry. Questions are informative of the knowledge domain as a context for inquiry and the domain criteria for what constitutes an answer and how the answer should be produced, which in turn inform the criteria for relevant documents and their use in the production of knowledge. By making visible the knowledge domain as the context for question formulation, the essentially social nature of knowledge is acknowledged, and the informative nature of the question is unlocked. As a result, the centrality of the question as the underlying and organizing force of inquiry becomes readily apparent: in the alignment of the traditional focus of librarianship and documentalists on subject expertise with the current trend towards social epistemological as a foundational philosophy for LIS, in the reorientation of cognitive theories and models such as question negotiation towards the social context of knowledge domains, and in the clear definition of relevance as a relation between questions and documents. The pursuit of a deeper understanding of questions, in all of their omniscience and specificity, simultaneously produces knowledge about knowledge domains and the

products of their inquiries, as well as the formal nature of information- and knowledge-related phenomena themselves, such as questions and question formulation that emerge from the comparative study of knowledge domains.

## APPENDIX A: INTERVIEW PROTOCOL

*The overarching research question is: How, if at all, does the practice of questioning differ according to knowledge domains and what, if anything, do the differences reveal about the social epistemological nature of inquiry?*

### **Introduction**

“Hello! Nice to meet you and thank you so much for agreeing to be interviewed for my study.

“Before we begin, I’d just like to reconfirm that you are okay with the audio of this interview being recorded. I’m using Skype Call Recorder. I’m just going to drag in the “Callbot” in order to begin recording.

“I’d also like to confirm your:”

- Name:
- Doctoral program, University:
- Dissertation title:
- Current employment status:

Research statement:

“The purpose of this research is to study questioning from an information science perspective and how epistemology shapes question or topic formulation and information. I’m comparing dissertations produced in literature, neuroscience, and engineering to try to understand the types of research that are produced in each and the ways in which researchers’ interact with information throughout the research process.

### **Part I. Question type and formulation**

“I’d like to first ask you a series of questions about your dissertation topic and how you chose it.

QUESTIONS	PROMPTS
<p><b>1. Please tell me what your dissertation is about.</b></p> <p><i>OR</i></p> <p>Give me an overview of your dissertation.</p>	<p>Please point out to me where in your dissertation you state or summarize what your dissertation is about.</p> <p>What terminology do people in your field use to identify what research projects are “about” (RQs, hypotheses, research “problem,” research “area,” topic, etc.?)</p>

<p><b>2a. Why did you choose this as your dissertation topic?</b> <i>OR</i> Describe to me your process of choosing/shaping a dissertation topic.</p>	<p>How typical is this (your process) compared to others in your field? <i>OR</i> Is that typically why people in your field choose/shape their topics?</p>
<p><b>2b. Any other factors that influenced the development of your dissertation topic?</b> (For instance, exposure to certain texts (print/digital), other media (audio/visual), people, experiences (incl. conferences)...) )</p>	<p>Where were these info/data sources found? How did you use them? How did you know which resources to use? i.e., Why these and not others?</p>
<p><b>3. Did your topic or formulation of the topic (research questions) change over time? How?</b></p>	<p>What led to the change? What effect did this change have on your research process?</p>

## **Part II. Information resources and information activities**

“Next, I’d like to go through your dissertation with you, chapter by chapter, and have you to talk about the types of data/information sources/resources\* that you used throughout and how you used them.

*(Information resources may include artifacts (print/digital texts, other media, technology, equipment, objects), people, or experiences (Hartel, 2001))*

<b>QUESTIONS</b>	<b>PROMPTS</b>
<p>Let’s look at:</p> <ul style="list-style-type: none"> <li>• Chapter 1</li> <li>• Chapter 2</li> <li>• Chapter 3</li> <li>• Chapter 4</li> <li>• Chapter 5</li> </ul> <p><b>4. What data/information sources/resources did you use?</b></p>	<p>How did you know which to use? i.e., Why these and not others? How did you use them? How did you know how to use with them?</p>
<p><b>5. What data/information sources/resources did you use that didn’t make it into your bibliography?</b></p>	<p>Why didn’t you include them? How did you know not to include them?</p>
<p><b>6. What data/information sources/resources did you decide NOT to use?</b></p>	<p>Why didn’t you use these? How did you know not to include these?</p>
<p><b>7. What factors, outside of your own intellectual</b></p>	<p>Funding, academic experiences,</p>

interests, affected the dissertation process?	advisor/committee, colleagues, work/life experience, access to info/tech, etc.?
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### Part III. The knowledge domain

I am interested in how you define your academic field and where you situate yourself and your dissertation in relation to your field.

QUESTIONS	PROMPTS
<p><b>8. How would you define your field/discipline?</b> <i>OR</i> WHAT'S IT ABOUT? What types of topics/problems/questions is your field concerned with? What are the core areas of research in your field? What does research in your field look like?</p>	<p>Examples? Why (is this relevant)? How did you learn this/do you know this?</p>
<p><b>9. What are some things that distinguish your field/discipline from other closely related fields/disciplines?</b> <i>OR</i> WHAT'S IT NOT ABOUT? What types of topics/problems/questions do NOT concern your field? What areas of research are outside of/adjacent to your field? What's NOT allowed?</p>	<p>Examples? Why (is this NOT relevant)? How did you learn this/do you know this?</p>
<p><b>10. What would you change about your field, if you could, in terms of the type of research that it produces?</b></p>	<p>Questions/topics/methods that it should expand into? Questions/topics/methods it should abandon?</p>
<p><b>11. Where do you place yourself and your research in the context of your field?</b></p>	<p>Who is the audience for your dissertation? What has response been? Was this what you expected?</p>
<p>Anything else you'd like to comment on?</p>	

## APPENDIX B: IDENTIFICATION OF DOMAINS' QUESTION FORMULATIONS

<i>ID</i>	<i>Abstract segment</i>	<i>Question</i>
N1	Using Hebb's theory of neuroplasticity and the principle of automaticity as theoretical bases, this experimental study examined the effectiveness of a specific 12-week neuroscience-based, cognitive-skills computer-training program on the cognitive processing of 40 elementary students in grades 2-4 with specific learning disabilities (SLD).	Whether cognitive processing differs between an experimental group of elementary students in grades 2-4 with SLD receiving a 12-week neuroscience-based and a control group.
N2	This study aims to further elucidate whether verbal memory will be more severely impacted than nonverbal memory in this same bilingual pediatric TBI population. 18 children (M age =11.67 years (SD =3.7), 61% males, 50% bilingual) were assessed as part of a longitudinal study evaluating neuropsychological outcomes in moderate/ severe pediatric traumatic brain injury (TBI) at 3 m (Time 1) &12 m (Time 2) post-injury.	Whether verbal memory will be more severely impacted than nonverbal memory in a bilingual pediatric TBI population as compared to a monolingual population
N4	This dissertation presents the results of three original research studies characterizing the effects of acute, moderate doses of amphetamines on emotional memory in healthy humans.	Whether acute, moderate doses of amphetamines have an effect on emotional memory in healthy humans
N5	Using functional and structural neuroimaging techniques, I investigated the neural basis of conceptual memory networks in healthy adults and in patients with memory impairments resulting from neurodegenerative disease.	What is the neural basis of conceptual memory networks in healthy adults and in patients with memory impairments resulting from neurodegenerative disease?
N7	This dissertation tested the hypothesis that PAE leads to impairments in dentate gyrus-dependent learning and memory, which is associated with NMDA receptor--dependent LTP deficits and NMDA receptor subunit composition alterations in the dentate gyrus.	Whether PAE leads to impairments in dentate gyrus-dependent learning and memory in mice, which is associated with NMDA receptor--dependent LTP deficits and NMDA receptor subunit composition alterations in the dentate gyrus
N8	Across three experiments, I sought to (1) identify neural signals at retrieval corresponding to veridical memory and subsequent distortion and (2) determine if retrieval preferentially reinforces memory for information originally studied or information generated at retrieval.	Whether long-term memory is distorted by information erroneously retrieved from episodic memory
N9	This thesis tested predictions that the hippocampus is important in humans for remembering overlapping spatial events, and that flexible navigation of spatial routes is supported by key prefrontal and striatal structures operating in conjunction with the hippocampus.	(1) Whether the hippocampus is important in humans for remembering overlapping spatial events; (2) Whether flexible navigation of spatial routes is supported by key prefrontal and striatal structures operating in conjunction with the hippocampus.
N10	Using an associative memory paradigm of faces and names, the present study was conducted to investigate the memory deficits reported by ill	Whether memory deficits reported by and neurobiological correlates of encoding and performance of ill GWV differ from those

	GWV in a nationally representative sample comprised of both ill and well GWV.	of well GWV in a nationally representative sample.
N11	The present study sought to determine whether participants with moderate to severe traumatic brain injury (MOD/S TBI) would quantitatively and qualitatively differ from participants with no brain damage (NBD) in phonemic and semantic verbal fluency, and whether the potential differences may be attributed to working memory (WM) and information processing speed.	(1) Whether participants with moderate to severe traumatic brain injury (MOD/S TBI) would quantitatively and qualitatively differ from participants with no brain damage (NBD) in phonemic and semantic verbal fluency; (2) Whether the potential differences may be attributed to working memory (WM) and information processing speed
N12	Based on prior research, we hypothesized that in both experiments stress would impair memory updating.	Whether stress impairs memory updating
N15	In this thesis I combine information from each of these approaches to uncover the role of GC in learning.	What is the role of the gustatory cortex in learning?
N18	The purposes of the current study were to investigate the neural substrates of working memory and object location memory (OLM) after traumatic brain injury (TBI).	Whether the neural substrates of WM and OLM differ between healthy males and males with TBI
N20	The three studies presented in this dissertation investigated the practical utility and mnemonic mechanisms of a novel cognitive strategy designed to capitalize on self-referential processing: self-imagination.	What are the practical utility and mnemonic mechanisms of self-imagination?
N21	The work encompassed in this dissertation serves as an initial investigation for the role of histone lysine methylation mechanisms in regulating gene activation and suppression in the medial temporal lobe (MTL) that includes entorhinal cortex (EC), hippocampus, and amygdala during memory consolidation.	What is the role of histone lysine methylation mechanisms in regulating gene activation and suppression in the MTL during memory consolidation?
N22	This series of experiments developed novel paradigms involving the integration of conventional and ethologically relevant forms of reinforcement in the study of fear conditioning in rats.	What novel paradigms involving the integration of conventional and ethologically relevant forms of reinforcement can be developed that are most effective in the study of fear conditioning in rats?
N23	This dissertation aims to characterize the neural processes in association with the updating and storage of spatial information.	What are the neural processes in association with the updating and storage of spatial information?
N24	Using fear conditioning tasks, wherein subjects learn that a once neutral stimulus predicts an aversive event, we explored how the acquisition of an associative memory for a stimulus both depends upon and affects gamma oscillations.	How does the acquisition of an associative memory for a stimulus both depend upon and affects gamma oscillations?
N25	I investigate how place cells resolve conflicting neuronal input signals by developing computational models that integrate synaptic inputs on two scales.	How do place cells resolve conflicting neuronal input signals?
N26	The present work investigated age differences in the retrieval and definition of events from memory.	Whether retrieval and definition of events from memory differs between older and younger adults.
N27	The overarching aim of this dissertation was to	Whether and how emotion regulation goals

	examine how emotion regulation goals in particular might modulate autobiographical recall at both a behavioral and neural level.	modulate autobiographical recall at both a behavioral and neural level.
N30	We aimed to characterize the neural signature of “successful” cognitive aging (SCA), defined by working memory performance.	What is the neural signature of SCA, as defined by working memory performance?
N32	The second goal is to develop the adaptive training for patients with low visual working memory (VWM) capacity to improve cognitive abilities and healthy individuals who seek to enhance their intellectual performance.	What adaptive training can be developed for patients with low VWM capacity to improve cognitive abilities and healthy individuals who seek to enhance their intellectual performance?
N35	This work examines how episodic memories accumulate across longer time scales and multiple presentations by extending classic work of within-list effects of lists comprised of once-presented items.	How do episodic memories accumulate across longer time scales and multiple presentations?
N37	This dissertation describes a series of four experiments that use electrophysiological techniques to deconstruct familiarity memory in order to reveal the underlying operations of fluency.	What are the underlying neurocognitive interactions between fluency and familiarity memory?
N38	This dissertation investigates the functional processes of the medial temporal lobes (MTL) and the striatum (the input nucleus of the basal ganglia) during associative learning and memory.	What are the functional processes of the MTL and the striatum (the input nucleus of the basal ganglia) during associative learning and memory?
N39	This dissertation addresses the age-related reorganization of spatial and verbal working memory using three different, but complementary, methods.	How do spatial and working memory reorganize due to aging in the human brain?
N40	Suspecting that Bekkers and Stevens failed to consider a concept that was not available to them, electrical compartmentalization of distal dendrites and regenerative NMDA spikes, I reexamined their predictions with inclusion of factors required for dendritic spikes during signal read-out.	Whether Bekkers and Stevens alternate hypothesis, that information could be stored by the bound-but-blocked (non-conducting) state of the NMDA receptors, is confirmed with inclusion of factors required for dendritic spikes during signal read-out
N41	The ability to hold information in mind over a short period of time for future use is referred to as working memory (WM). This term typically refers to the maintenance of item information, such as locations or words. More recently, investigators have emphasized the importance of rules that establish relationships between those items and the pending response. This dissertation presents a series of studies investigating how our brains are able to flexibly hold or change the relevant rules held in mind.	How are our brains able to flexibly hold or the relevant rules of WM in mind?
N42	The present dissertation aims to delineate the influence of reward and punishment motivation on human declarative memory encoding and its underlying neural circuitry.	Whether reward and punishment motivation influences human declarative memory encoding and its underlying neural circuitry.
N43	Baseline data for 71 individuals with consensus-diagnosed mild cognitive impairment (MCI) enrolled in the Measuring Independent Living in the Elderly Study (MILES) was utilized to investigate patterns of verbal and visual learning	What are the patterns of verbal and visual learning and memory, as well as cognitive predictors of functional abilities in MCI, for 71 individuals with consensus-diagnosed MCI enrolled in the Measuring Independent

	and memory, as well as cognitive predictors of functional abilities in MCI.	Living in the Elderly Study (MILES) as compared to controls?
N44	In light of this shortcoming and more contemporary findings indicating a role of the 5-HT system in facilitating behavioral therapy for fear and anxiety related conditions, this dissertation will examine how new learning associated with the extinction of fear related memories may be mediated via actions involving 5-HT3 receptors and possible changes in GABAergic neurotransmission.	How is new learning associated with the extinction of fear related memories mediated via actions involving 5-HT3 receptors and possible changes in GABAergic neurotransmission?
N45	This thesis seeks to understand normative developmental aspects of memory systems implicated in psychopathology of anxiety and post-traumatic stress disorders. A common single nucleotide polymorphism in brain-derived neurotrophic factor, BDNF Val66Met, is highlighted due its associated role in aberrant fear learning in both humans and animal models, as is the developmental transition into and out of adolescence, when anxiety and affective disorders are most prevalent in human populations.	What is the role of BDNF Val66Met in aberrant fear learning in both humans and animal models, particularly during the developmental transition into and out of adolescence, when anxiety and affective disorders are most prevalent in human populations?
N47	Here, we wanted to further characterize the contribution of Cdh1 to learning and memory at both developmental and adult stages.	What is the contribution of Cdh1 to learning and memory at both developmental and adult stages?
N48	The present study examined prospective memory (ProM) and the relationship between ProM and everyday functioning in 33 Parkinson's disease (PD) patients and 26 demographically comparable adults.	Whether ProM and everyday functioning differs between between 33 PD patients and 26 demographically comparable adults
N49	To explore the role of small RNAs in memory-related synaptic plasticity we carried out massive parallel sequencing to profile the small RNAs of Aplysia.	What is the role of small RNAs in memory-related synaptic plasticity in Aplysia?
N51	This dissertation will demonstrate how psychostimulants can modulate memory processes and create addiction-like memories in mice.	How can psychostimulants modulate memory processes and create addiction-like memories in mice?

Table 1. Neuroscience: Inferring questions from declarative statements of researcher intent

N33	The, current study largely replicated findings from previous work that showed associative inference is possible with and without awareness.	Whether associative inference is possible with and without awareness.
N34	It has been suggested that visual attention can only be affected by consciously perceived events; however, we identified three novel and surprising results about the nature of attention and how it can influence our motor responses, memory and behavior without perceptual awareness.	What are the effects of attention without perceptual awareness on motor responses, memory, and behavior?
N46	The introduction of an updated version of the WMS, the Wechsler Memory Scale-4 <sup>th</sup> edition (WMS-IV), calls for additional resources especially for the specialized assessment of older	What alternate paragraph for the WMS-IV Older Adult Battery Logical Memory Subtest can be developed for the continued assessment of older adults?

	adults. An alternate paragraph (Morris Revision-IV) for the WMS-IV Older Adult Battery Logical Memory Subtest was developed to meet this need and shown to be psychometrically equivalent.	
N52	We find little evidence to support temporally based systems consolidation, and present data that supports the view that if the hippocampus is initially involved in learning a memory, it will always be necessary for accurate retrieval of that memory.	Whether systems consolidation is temporally based or not
N53	A computational cognitive neuroscience model is proposed, which models episodic memory based on the mammalian brain.	What computational cognitive neuroscience model of episodic memory based on the mammalian brain can be developed?
N54	One hypothesis that has been proposed to account for these inconsistent findings is that the response of some brain regions subserving working memory (WM) task performance to parametrically increasing WM load, most critically dorsolateral prefrontal cortex, may in fact be non-monotonic in nature; that is, at sufficiently high loads activation in these regions may begin to decrease.... To date, this hypothesis has not been directly tested; however, I report here the results of a series of studies using the self-ordered working memory task that clearly demonstrate such an 'inverted-U' in healthy participants that is absent in patients with schizophrenia.	Whether healthy patients demonstrate an "inverted-U" response to the self-ordered WM task that is absent in patients with schizophrenia.

Table 2. Neuroscience: Inferring questions from answer

ID	Abstract segment	Question
N3	Title: The electrophysiological and neural correlates of associative memory in humans	What are the electrophysiological and neural correlates of associative memory?
N6	Title: The role of the atypical Protein Kinase C zeta orthologue, PKC Apl III, in synaptic plasticity and long term memory in <i>Aplysia californica</i>	What is the role of the atypical Protein Kinase C zeta orthologue, PKC Apl III, in synaptic plasticity and long term memory in <i>Aplysia californica</i> ?
N13	Title: Chronic Treatment with the Serotonin 2A Antagonist SR 46349B Enhances Retention and Efficiency of Rule-Guided Behavior in Mice	Whether chronic treatment with the serotonin 2A antagonist SR 46349B enhances retention and efficiency of rule-guided behavior in mice
N14	Title: Autobiographical Memory Retrieval to Musical Cues in Healthy Older Adults	Whether autobiographical memory retrieval to musical cues differs between healthy older adults and younger adults
N16	Title: Children diagnosed with ADHD and children diagnosed with ADHD with comorbid anxiety or depression: Exploring the differences in working memory performance	Whether working memory performance differs between children diagnosed with ADHD and children diagnosed with ADHD with comorbid anxiety or depression
N17	Title: The elucidation of the role of Homer1c in hippocampal function	What is the role of Homer1c in hippocampal function?
N19	Title: The Mechanisms of Proactive Interference and Their Relationship with Working Memory	What are the mechanisms of proactive interference and their relationship with working memory?
N28	Title: Investigating the Role for Dysbindin in	What is the role of dysbindin in

	Hippocampal-Dependent Learning and Memory: Glutamatergic Mechanisms	hippocampal-dependent learning and memory?
N29	Title: Conceptual flexibility: Behavioral and neural variations in semantic memory retrieval	What are the behavioral and neural variations in semantic memory retrieval?
N31	Title: Time and distance coding by the hippocampus and medial entorhinal cortex	What is the role of the hippocampus and medial entorhinal cortex in time and distance coding?
N36	Title: The interaction of mammalian target of rapamycin and extracellular signal-regulated kinase during memory consolidation	What are the interactions of mammalian target of rapamycin and extracellular signal-regulated kinase during memory consolidation?
N50	Title: The Role of Hippocampal Brain Rhythms and Neural Spikes in Episodic Memory Processes	What is the role of hippocampal brain rhythms and neural spikes in episodic memory processes?

Table 3. Neuroscience: Inferring questions from the title

ID	Abstract segment
L15	How does a woman writer memorialize her own traumatic history, when it happens to be part of a larger History dominated by male narratives (as far as Holocaust and slavery go), or when it is altogether silenced (as is the case for madness and institutionalization)?

Table 4. Literature: Explicitly stated question

ID	Abstract segment	Question
L1	This thesis will provide a comparative analysis of the poetics of traumatic hindsight and the literary devices that three texts – Anne Michaels's <i>Fugitive Pieces</i> , Linda Hogan's <i>Solar Storms</i> , and Toni Morrison's <i>Beloved</i> – utilize to signify the necessity of a retrospective gaze towards the atrocious past.	What are the poetics of traumatic hindsight and the literary devices that three texts – Anne Michaels's <i>Fugitive Pieces</i> , Linda Hogan's <i>Solar Storms</i> , and Toni Morrison's <i>Beloved</i> – utilize to negotiate the fragmentation that characterizes the traumatic aftermath and signify the necessity of a retrospective gaze towards the atrocious past?
L2	I analyze the use of the idiom of heritage as well as a traditional idiom of kinship that has come to be handed down as a Zulu language for mediating social relations by the uBumbano in ways that challenge the centrality given to Shaka in narrations of the past. I argue that the uBumbano is using these idioms against how they are commonly understood - heritage as a mode of engaging with the past for its feel-good features and kinship as a Zulu idiom in KwaZulu-Natal province.	How are the uBumbano using the idiom of heritage, as well as a traditional idiom of kinship that has come to be handed down as a Zulu language for mediating social relations by the uBumbano, in ways that challenge the centrality given to Shaka in narrations of the past?
L3	This dissertation analyzes how these women writers use various aesthetics in portraying the landscape of memories to represent, redefine, and transcend repetition, trauma, and loss, and to renegotiate the reality of the past, present, and future.	How do Marguerite Duras (1914-1996), Eileen Chang (1920-1995), and Maxine Hong Kingston (1940-), women writers who share transnational experiences and express various types of traumatic loss in their works, use various aesthetics in portraying the landscape of memories to represent, redefine, and transcend repetition, trauma, and loss, and to

		renegotiate the reality of the past, present, and future?
L4	By choosing some exemplary fiction and film texts from Zimbabwe and South Africa, I seek to examine certain tendencies in the scholarship surrounding the extremely violent processes often reduced to the familiar and somewhat simplistic phrase, "the liberation struggle." Broadly, I interrogate the relationship between the violence of the events so described and the memory of them in the selected films and fiction.	What is the relationship between the violence of the events of the "liberation struggle" in Zimbabwe and South Africa and the memory of them in selected exemplary fiction and film texts?
L5	In my dissertation, "History as Myth and Memory: Bassani, Ginzburg, Levi, and the Re-membering of Fascism" I examine how post-war literature has affected the ways in which Italy has dealt with the memory of Fascism's twenty year rule.	How has post-war literature created an alternate and competing memory of Fascism's twenty-year rule?
L6	The dissertation demonstrates how Andrea Camilleri provides a "security blanket" for his readers: by including many elements of a common cultural memory, he keeps his readers safely anchored.	How does Andrea Camilleri use a common cultural memory to provide a "security blanket" for his readers and keeping his readers safely anchored?
L8	This dissertation attempts to locate a nexus of aesthetic theory, historical memory, and emergent "community" that is inherently heterogeneous and does not revolve around an exemplary subject.	Where is the nexus of aesthetic theory, historical memory, and emergent "community" that is inherently heterogeneous and does not revolve around an exemplary subject?
L9	This dissertation concerns the fate of a particular object of French collective memory, François Fénelon, investigating how references to his name in nineteenth-century literature through to the writings of Proust reflect and affect the changing French imagination of him whose posterity became a standard for the remembrance of grands hommes and pantheonization in the nineteenth century.	How do references to the name of Fenelon in nineteenth-century literature through to the writings of Proust reflect and affect the changing French imagination of him whose posterity became a standard for the remembrance of grands hommes and pantheonization in the nineteenth century?
L10	This dissertation examines how postmodernist narratives of memory in Graham Swift's <i>Waterland</i> , Salman Rushdie's <i>Midnight's Children</i> , and Amitav Ghosh's <i>The Shadow Lines</i> retrieve the stories of those who have been lost or forgotten in official history and refigure the temporal and spatial imaginary in intertwining personal stories of crisis with public history through acts of remembering.	How do postmodernist narratives of memory in Graham Swift's <i>Waterland</i> , Salman Rushdie's <i>Midnight's Children</i> , and Amitav Ghosh's <i>The Shadow Lines</i> retrieve the stories of those who have been lost or forgotten in official history and refigure the temporal and spatial imaginary?
L11	This dissertation focuses on the construction of the narrated environment in W. G. Sebald's <i>Die Ausgewanderten</i> , <i>Die Ringe des Saturn</i> , and <i>Austerlitz</i> . Drawing on a constellation of ecocritical theories, I examine the ways in which memory and history are embedded in images of the built environment and how, in turn, this spatialization of the past contributes to a criticism of traditional linear narration.	How are memory and history embedded in images of the built environment of W. G. Sebald's <i>Die Ausgewanderten</i> , <i>Die Ringe des Saturn</i> , and <i>Austerlitz</i> ? How, in turn, does this spatialization of the past contribute to a criticism of traditional linear narration?
L12	The dissertation considers how intergenerational, trans-temporal trauma becomes re-narrativized and re-envisioned over time in four symbolic sites of slavery (five countries)--Africa (Ghana and Mozambique), the Caribbean (Cuba), Brazil, and the United States)--with the	How does intergenerational, trans-temporal trauma become re-narrativized and re-envisioned over time in four symbolic sites of slavery (five countries)--Africa (Ghana and

	goal of exposing differences and emphasizing ruptures.	Mozambique), the Caribbean (Cuba), Brazil, and the United States)--with the goal of exposing differences and emphasizing ruptures?
L13	Resisting the postmodern posthistorical approach of the image, this dissertation demonstrates how, conceived as spaces of memories, the United States and Mexico become the loci of cultural becoming for France and the United States.	How, conceived as spaces of memories, do the United States and Mexico become the loci of cultural becoming for France and the United States?
L18	I argue that the European postcolonial and migrant literature I read claims the history of the Jewish Question and Holocaust memory as critical resources for Europe's new migrants and diasporic communities	How does the European postcolonial and migrant literature I read claim the history of the Jewish Question and Holocaust memory as critical resources for Europe's new migrants and diasporic communities?
L19	The aim of the present study is to explore different strategies - both rhetorical and political - "Franco's children" used at three key historical moments: 1) the transition to democracy in the early 1980s; 2) the mid and later 1990s; and 3) the period following the Law of Historical Memory [October 31, 2007].	What are the different strategies - both rhetorical and political - "Franco's children" used at three key historical moments: 1) the transition to democracy in the early 1980s; 2) the mid and later 1990s; and 3) the period following the Law of Historical Memory [October 31, 2007] by "Franco's children" in <i>El Sur</i> , <i>El florido pensil</i> , <i>Habíamos ganado la guerra</i> , and <i>La gloria de los niños</i> ?
L20	This study examines the relationship between the Latin American journalistic crónica ("chronicle") and memory, specifically the way writers used highly imaginative crónicas as a means to uphold or challenge official memory and history and to propose "alternative" readings of the nation during Mexico's centenary and bicentenary commemorations of Independence of 1910, 1921, and 2010.	How do writers use highly imaginative crónicas as a means to uphold or challenge official memory and history and to propose "alternative" readings of the nation during Mexico's centenary and bicentenary commemorations of Independence of 1910, 1921, and 2010?

Table 5. Literature: Inferring questions from declarative statements of researcher's intent

ID	Abstract segment	Question
L14	Title: Remembering Modernity: Techniques of Temporal Memory in Twentieth-Century Literature and Film	What are the techniques of temporal memory in twentieth-century modernist and post-modernist literature and film?

Table 6. Literature: Inferring questions from the title

ID	Abstract segment	Question
L7	The dissertation explores the specific memories of the protagonist, Bradley Scott. However, at a deeper level of abstraction it is about a collective memory and how we as humans and creative artist continue to grapple with, and attempt to reorder, our memories.	What is the nature of memory (individual vs. collective)? How do we as humans and creative artist continue to grapple with, and attempt to reorder, our memories?

L16	<i>Veiled Men</i> is about a woman's struggle to regain her sense of belonging, having lost her memory after being injured in a violent attack. The focus of the novel involves the collectivity of memory and the way patriarchal culture ignores and ultimately punishes women's anger and desire?	What is the nature of memory (individual vs. collective)? How does patriarchal culture ignore and ultimately punish women's anger and desire?
L17	<i>Creatures after Their Kind</i> is a collection of six short stories that explores the importance of myth, memory, tradition, and place within a Southern context.	What is the importance of myth, memory, tradition, and place within a Southern context?

Table 7. Literature: Inferring questions from descriptions of “about”-ness

ID	Abstract segment	Question
CE3	This dissertation addresses the problem of providing transactional support for fast, non-volatile memories that exploits their raw performance and makes programming easy.	How can transactional support be provided for fast, non-volatile memories that exploits their raw performance and makes programming easy?
CE8	In order to find an efficient alternative to existing coherence mechanisms while still maintaining shared memory, we believe that hardware must be able to exploit the semantic information available in software.	What is an efficient alternative model to existing coherence mechanisms that facilitates the transfer of semantic information from software to hardware and still maintains shared memory?
CE10	This work focuses on reliable, low-power methodologies for SRAM memories.	What are reliable, low-power methodologies for SRAM memories?
CE12	This work considers the versatility and scope of nanoscale devices, in particular the memristor, when employed in different nanoelectronic and hybrid CMOS/Nano circuits to realize several flavors of memory and logic implementations.	How should several flavors of memory and logic implementation be realized, considering the versatility and scope of nanoscale devices, in particular the memristor, when employed in different nanoelectronic and hybrid CMOS/Nano circuits?
CE19	Therefore, this dissertation is targeted at exploring and exploiting the spatiotemporal interactions in LLC capacity management to improve CMPs' performance.	How can the spatiotemporal interactions in LLC capacity management be exploited to improve CMP's performance?

Table 8. Computer engineering: Inferring questions from declarative statements of researcher intent

ID	Abstract segment	Question
CE1	For example, NAND SSDs have excellent random read latency; however, they have a relatively slow random write performance. This means that any architecture utilizing these devices should leverage their desirable features while hiding their drawbacks. The primary focus of this work is on how NAND SSDs should be integrated into the memory hierarchy. This work therefore proposes an architectural approach tailored to mitigate the SSD drawbacks while leveraging their performance advantages.	What memory architecture mitigates the drawbacks of NAND SSDs (relatively slow random write performance) while leveraging their performance advantages (excellent random read latency)?
CE11	DRAM memory has always been in staple in the memory solutions domain, and it appears that it will continue to be in the near future. The versatility of DRAM memory has enabled it to be utilized in	(1a) What are the undesirable design traits of DRAM? (1b) How can

	many different applications. However, DRAM memory does have undesirable characteristics that are innate simply due to its design. In this dissertation, we identify these design traits and offer either tools or propose different solutions to aid in mitigating the effects of those undesirable traits.	their effects be mitigated?
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Table 9. Computer engineering: Inferring questions from declarative statements of researcher intent in context

ID	Abstract segment	Question
CE2	This dissertation introduces PHiLOSoftware , a Low Power, High Performance, Reliable, and Secure Virtualization Layer for On-Chip Software-Controlled Memories. PHiLOSoftware allows designers to build memory allocation policies to efficiently manage the distributed on-chip memory resources at a high level.	How can designers build memory allocation policies to manage the distributed on-chip memory resources at a high level?
CE4	A hardware verified simulation suite is developed to accurately model and evaluate the behavior of this buffer-on-board memory system. A study of this design space is performed to determine optimal use of the resources involved.	What is the behavior of the buffer-on-board memory system? What is the optimal use of the resources involved?
CE6	The memory hierarchy extends from on-chip caches through persistent storage in I/O subsystems, and we analyze and develop models of shared data and cache use to understand how parallel applications interact with hardware and why parallel scalability is often poor. Through this lens of these memory models, we develop dynamic optimization techniques for disparate layers of the memory hierarchy.	What dynamic optimization techniques, driven by models of shared data and cache use, can be developed for disparate layers of the memory hierarchy?
CE7	This dissertation presents a novel cache prefetching model, out of context cache prefetching, that allows for prefetching data beyond context switch boundaries by predicting the next runnable process.... The goal of Out of Context Cache Prefetching and Inter-Context Eviction Prefetching is to eliminate context-switch misses.	What model of cache memory can be developed that eliminates context switch misses?
CE9	This thesis presents four different approaches to design and analyze robust low voltage SRAM: SRAM analysis method improvement, SRAM bitcell development, SRAM peripheral optimization, and advance device selection.	What are the possible approaches to designing and analyzing robust low voltage SRAM?
CE13	There is a large body of research in the psychology domain regarding the structure of cognitive resources. In particular, Baddeley's multi-component model of working memory describes a separation between the resources used for verbal and non-verbal storage and processing. It is likely that semi-natural locomotion techniques (in virtual reality systems) require some of these resources, which will then be unavailable for concurrent tasks. A pair of studies was conducted, investigating the cognitive resource requirements of several atomic locomotion movements by manipulating the user interface and field of view.	What are the cognitive resource requirements of several atomic locomotion movements in a virtual reality system with a semi-natural locomotion interface?
CE16	In this dissertation, we have devised an innovative approach to dynamically set supply voltages and refresh cycle for Dynamic Random Access Memory (DRAM) and 1T1C embedded Dynamic Random Access Memory (eDRAM). The approach helps us to reduce power consumption.	What approach should be taken to dynamically set supply voltages and refresh cycle for Dynamic Random Access Memory (DRAM) and 1T1C embedded Dynamic Random Access Memory (eDRAM) in

		order to reduce power consumption?
CE17	This dissertation presents optimizations of the on-chip memory of embedded systems from various angles including on-chip cache arrangement, iteration and task scheduling, and cache replacement policies.	What are the various angles on optimizing the on-chip memory of embedded systems?
CE18	In this dissertation, we study every major element of the memory system--the memory chip, the processor-memory channel, the memory access mechanism, and memory reliability, and identify the key bottlenecks to efficiency.	What are the key bottlenecks to efficiency of the memory system?

Table 10. Computer engineering: Inferring questions from answers

ID	Abstract segment	Question
CE5	<p>P: Programming languages implement memory (or consistency) models that require other memory references to be executed in order, beyond those guaranteed to execute in order by the relaxed consistency model processor, i.e., they have a stricter memory model. An extreme example of a stricter memory model is the sequentially consistent memory model. A stricter model is thought by many to be easier to reason about than a relaxed model. Current processors provide fence instructions that allow these stricter orders to be enforced.</p> <p>A: We present a flow-based fence insertion algorithm for effectively enforcing the orders required.</p>	What algorithm can effectively enforce stricter memory models in parallel processors, such as the sequentially consistent memory model?
CE14	<p>P: Spin-transfer torque magnetic tunnel junctions (STT-MTJs) have potential for low power, nonvolatile dense memory and logic. But many proposals require fine grain integration with CMOS, thereby increasing fabrication costs and circuit overhead.</p> <p>A: We introduce magnetic memory and logic circuits (mLogic) that have minimal connections to CMOS.</p>	How should logic circuits and their signal representations be configured in order to allow low power, nonvolatile dense memory and logic with minimal connections to CMOS?
CE15	<p>P: Main memory capacity is becoming a critical issue for modern server systems. Unfortunately, current trends suggest that meeting these capacity requirements using DRAM will not be ideal. DRAM consumes significant amounts of energy (idle, refresh, and precharge energies) and will soon reach its density limit. Many researchers in industry and academia point to Phase-Change Memory (PCM) technology as a promising replacement for DRAM. PCM is byte-addressable as DRAM, but presents higher density and lower idle power consumption than DRAM. However, PCM is also slower than DRAM and has limited endurance. For these reasons, hybrid memory systems that combine a small amount of DRAM and a large amount of PCM have become attractive.</p> <p>A: In this dissertation, we propose two hybrid memory systems for servers. The first system (called Rank-aware Page Placement or RaPP) is a hardware-driven page placement policy.</p>	What hybrid DRAM-PCM memory systems for servers provide robust and consistent memory performance without sacrificing energy?
CE20	<p>P: The emerging Phase Change Memory (PCM) technology is drawing increasing attention due to its advantages in non-volatility, byte-addressability and scalability. It is regarded as a promising candidate for future main memory. However, PCM's write operation has some limitations that pose challenges to its application in memory. The disadvantages include long write latency, high write power and limited write endurance.</p>	How can PCM memory, given its long write latency, high write power and limited write endurance, be successfully applied?

	A: In this thesis, I present my effort towards successful application of PCM memory	
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Table 11. Computer engineering: Inferring questions from juxtaposition of problem statements and answers

## APPENDIX C: DOMAIN QUESTIONS, ACCORDING TO CONTENT AND FORM

<i>ID</i>	<i>Question</i>	<i>Form</i>
N3	What are the electrophysiological and neural correlates of associative memory?	Research question (RQ)
N5	What is the neural basis of conceptual memory networks in healthy adults and in patients with memory impairments due to neurodegenerative disease?	RQ
N30	What is the neural signature of “successful” cognitive aging (SCA), as defined by working memory performance?	RQ

Table 1. Neuroscience: Queries of substance/definition about the neural correlates of memory

<i>ID</i>	<i>Question</i>	<i>Form</i>
<i>Anatomical</i>		
N9	(1) Whether the hippocampus is important in humans for remembering overlapping spatial events; (2) Whether flexible navigation of spatial routes is supported by key prefrontal and striatal structures operating in conjunction with the hippocampus.	Hypothesis (HYP)
N15	What is the role of the gustatory cortex in learning?	RQ
N31	What is the role of the hippocampus and medial entorhinal cortex in time and distance coding?	RQ
N38	What are the functional processes of the medial temporal lobes (MTL) and the striatum (the input nucleus of the basal ganglia) during associative learning and memory?	RQ
N50	What is the role of hippocampal brain rhythms and neural spikes in episodic memory processes?	RQ
<i>Neuronal</i>		
N6	What is the role of the atypical Protein Kinase C zeta orthologue, PKC Apl III, in synaptic plasticity and long term memory in <i>Aplysia californica</i> ?	RQ
N17	What is the role of Homer1c in hippocampal function?	RQ
N21	What is the role of histone lysine methylation mechanisms in regulating gene activation and suppression in the medial temporal lobe during memory consolidation?	RQ
N28	What is the role of dysbindin in hippocampal-dependent learning and memory?	RQ
N36	What are the interactions of mammalian target of rapamycin and extracellular signal-regulated kinase during memory consolidation?	RQ
N45	What is the role of BDNF Val66Met in aberrant fear learning in both humans and animal models, particularly during the developmental transition into and out of adolescence, when anxiety and affective disorders are most prevalent in human populations?	RQ
N47	What is the contribution of Cdh1 to learning and memory at both developmental and adult stages?	RQ
N49	What is the role of small RNAs in memory-related synaptic plasticity in <i>Aplysia</i> ?	RQ
N51	How can psychostimulants modulate memory processes and create addiction-like memories in mice?	RQ

Table 2. Neuroscience: Queries of character/description about the role of *X* in memory

<i>ID</i>	<i>Question</i>	<i>Form</i>
N8	Whether long-term memory is distorted by information erroneously retrieved from episodic memory	HYP
N19	What are the mechanisms of proactive interference and their relationship with working memory?	RQ
N23	What are the neural processes in association with the updating and storage of spatial information?	RQ
N24	How does the acquisition of an associative memory for a stimulus both depend upon and affects gamma oscillations?	RQ
N25	How do place cells resolve conflicting neuronal input signals?	RQ
N29	What are the behavioral and neural variations in semantic memory retrieval?	RQ
N34	What are the effects of attention without perceptual awareness on motor responses, memory, and behavior?	RQ
N35	How do episodic memories accumulate across longer time scales and multiple presentations?	RQ
N37	What are the underlying neurocognitive interactions between fluency and familiarity memory?	RQ
N39	How do spatial and working memory reorganize due to aging in the human brain?	RQ
N40	Whether Bekkers and Stevens alternate hypothesis, that information could be stored by the bound-but-blocked (non-conducting) state of the NMDA receptors, is confirmed with inclusion of factors required for dendritic spikes during signal read-out.	HYP
N41	How are our brains able to flexibly hold the relevant rules of working memory in mind?	RQ
N44	How is new learning associated with the extinction of fear related memories mediated via actions involving 5-HT3 receptors and possible changes in GABAergic neurotransmission?	RQ
N52	Whether systems consolidation is temporally based or not.	HYP
N56	What is the function of reward and flexible learning systems in value-guided decision making? How does ongoing reward learning modulate memory formation in the hippocampus?	RQ

Table 3. Neuroscience: Queries of character/description about the neural mechanisms of memory

<i>ID</i>	<i>Question</i>	<i>Form</i>
<i>Diseases and disorders</i>		
N10	Whether memory deficits reported by and neurobiological correlates of encoding and performance of ill GWV differ from those of well GWV in a nationally representative sample.	HYP
N16	Whether working memory performance differs between children diagnosed with ADHD and children diagnosed with ADHD with comorbid anxiety or depression.	HYP
N43	What are the patterns of verbal and visual learning and memory, as well as cognitive predictors of functional abilities in MCI, for 71 individuals with consensus-diagnosed MCI enrolled in the Measuring Independent Living in the Elderly Study (MILES) as compared to controls?	HYP
N48	Whether everyday functioning differs between between 33 PD patients and 26 demographically comparable adults	HYP
N54	Whether healthy patients demonstrate an “inverted-U” response to the self-ordered WM task that is absent in patients with schizophrenia.	HYP
<i>Traumatic brain injury</i>		
N2	Whether verbal memory will be more severely impacted than nonverbal memory in a bilingual pediatric TBI population as compared to a monolingual population.	HYP
N11	(1) Whether participants with moderate to severe traumatic brain injury (MOD/S TBI)	HYP

	would quantitatively and qualitatively differ from participants with no brain damage (NBD) in phonemic and semantic verbal fluency; (2) Whether the potential differences may be attributed to working memory (WM) and information processing speed	
N18	Whether the neural substrates of working memory and object location memory differ between healthy males and males with traumatic brain injury.	HYP
<i>Age</i>		
N14	Whether autobiographical memory retrieval to musical cues differs between healthy older adults and younger adults	HYP
N26	Whether retrieval and definition of events from memory differs between older and younger adults.	HYP
<i>Individual differences</i>		
N33	Whether associative inference is possible with and without awareness.	HYP

Table 4. Neuroscience: Queries of conditionality about *Y* and memory

<i>ID</i>	<i>Question</i>	<i>Form</i>
<i>Cognitive interventions</i>		
N1	Whether the experimental group receiving a 12-week neuroscience-based, cognitive-skills computer-training program differs from the control group on the cognitive processing of 40 elementary students in grades 2-4 with specific learning disabilities (SLD).	HYP
N20	What are the practical utility and mnemonic mechanisms of self-imagination?	HYP
N27	Whether emotion regulation goals modulate autobiographical recall at both a behavioral and neural level.	HYP
N42	Whether reward and punishment motivation influences human declarative memory encoding and its underlying neural circuitry.	HYP
<i>Drugs</i>		
N4	Whether amphetamines affect emotional memory	HYP
N7	Whether PAE leads to impairments in dentate gyrus-dependent learning and memory, which is associated with NMDA receptor--dependent LTP deficits and NMDA receptor subunit composition alterations in the dentate gyrus.	HYP
N13	Whether chronic treatment with the serotonin 2A antagonist SR 46349B enhances retention and efficiency of rule-guided behavior in mice.	HYP
<i>Stress</i>		
N12	Whether stress impairs memory updating	HYP
<i>Mode of presentation</i>		
N57	Whether there is a difference in the quantity of episodic memory that is stored when the presentation of linguistic materials is visual (read by the individual) versus auditory (heard by the individual).	HYP

Table 5. Neuroscience: Queries of biconditionality about *Z* and memory

<i>ID</i>	<i>Question</i>	<i>Form</i>
N55	Whether implicit memory and learning strategies, including high-repetition practice, errorless learning (EL), and spaced retrieval (SR) improve objective measures of balance, performance on the Timed Up and Go test (TUG), and self-selected gait speed (ssGS).	HYP

Table 6. Neuroscience: Query of biconditionality about memory and *A*

<i>ID</i>	<i>Question</i>	<i>Form</i>
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N22	What novel paradigms can be developed involving the integration of conventional and ethologically relevant forms of reinforcement in the study of fear conditioning in rats?	GOAL
N32	What adaptive training can be developed for patients with low visual working memory (VWM) capacity to improve cognitive abilities and healthy individuals who seek to enhance their intellectual performance?	GOAL
N46	What psychometrically equivalent alternate paragraph (Morris Revision-IV) for the WMS-IV Older Adult Battery Logical Memory Subtest can be developed for the specialized assessment of older adults?	GOAL
N53	What computational cognitive neuroscience model can be developed which models episodic memory based on the mammalian brain?	GOAL

Table 7. Neuroscience: Queries of rationale/explication about memory models or instruments

<i>ID</i>	<i>Question</i>	<i>Form</i>
<i>General</i>		
L6	How does Andrea Camilleri use a common cultural memory to provide a "security blanket" for his readers and keeping his readers safely anchored?	Topic (TOP)
L13	How, conceived as spaces of memories, do the United States and Mexico become the loci of cultural becoming for France and the United States?	TOP
L18	How does the European postcolonial and migrant literature I read claim the history of the Jewish Question and Holocaust memory as critical resources for Europe's new migrants and diasporic communities?	TOP
<i>To challenge historical memory</i>		
L2	How are the uBumbano using the idiom of heritage, as well as a traditional idiom of kinship that has come to be handed down as a Zulu language for mediating social relations by the uBumbano, in ways that challenge the centrality given to Shaka in narrations of the past?	TOP
L5	How has post-war literature created an alternate and competing memory of Fascism's twenty-year rule?	TOP
L10	How do postmodernist narratives of memory in Graham Swift's <i>Waterland</i> , Salman Rushdie's <i>Midnight's Children</i> , and Amitav Ghosh's <i>The Shadow Lines</i> retrieve the stories of those who have been lost or forgotten in official history and refigure the temporal and spatial imaginary?	TOP
L20	How do writers use highly imaginative crónicas as a means to uphold or challenge official memory and history and to propose "alternative" readings of the nation during Mexico's centenary and bicentenary commemorations of Independence of 1910, 1921, and 2010?	TOP
<i>To negotiate trauma</i>		
L1	What are the poetics of traumatic hindsight and the literary devices that three texts utilize to negotiate the fragmentation that characterizes the traumatic aftermath and signify the necessity of a retrospective gaze towards the atrocious past?	TOP
L3	How do these women writers use various aesthetics in portraying the landscape of memories to represent, redefine, and transcend repetition, trauma, and loss, and to renegotiate the reality of the past, present, and future?	TOP
L15	How does a woman writer memorialize her own traumatic history, when it happens to be part of a larger History dominated by male narratives (as far as Holocaust and slavery go), or when it is altogether silenced (as is the case for madness and institutionalization)?	TOP

Table 8. Literature: Queries of rationale/explication about the literary uses of memory

<i>ID</i>	<i>Question</i>	<i>Form</i>
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L4	What is the relationship between the violence of the events of the "liberation struggle" in Zimbabwe and South Africa and the memory of them in selected exemplary fiction and film texts?	TOP
L8	Where is the nexus of aesthetic theory, historical memory, and emergent "community" that is inherently heterogeneous and does not revolve around an exemplary subject?	TOP
L11	How are memory and history embedded in images of the built environment? How, in turn, does this spatialization of the past contribute to a criticism of traditional linear narration?	TOP
L12	How does intergenerational, trans-temporal trauma become re-narrativized and re-envisioned over time in four symbolic sites of slavery (five countries)--Africa (Ghana and Mozambique), the Caribbean (Cuba), Brazil, and the United States)--with the goal of exposing differences and emphasizing ruptures?	TOP
L14	What are the technics of temporal memory in twentieth-century modernist and post-modernist literature and film?	TOP
L19	What are the different strategies - both rhetorical and political - "Franco's children" used at three key historical moments: 1) the transition to democracy in the early 1980s; 2) the mid and later 1990s; and 3) the period following the Law of Historical Memory [October 31, 2007] by "Franco's children" in El Sur, El florido pensil, Habiamos ganado la guerra, and La gloria de los ninos?	TOP

Table 9. Literature: Queries of rationale/explication about the literary construction of memory

<i>ID</i>	<i>Question</i>	<i>Form</i>
L9	How do references to the name of Fenelon in nineteenth-century literature through to the writings of Proust reflect and affect the changing French imagination of him whose posterity became a standard for the remembrance of grands hommes and pantheonization in the nineteenth century?	TOP

Table 10. Literature: Queries of rationale/explication about the cultural memory of a literary figure

<i>ID</i>	<i>Question</i>	<i>Form</i>
L7	What is the nature of memory? How do we as humans and creative artist continue to grapple with, and attempt to reorder, our memories?	Theme (THE)
L16	What is the nature of memory? How does patriarchal culture ignore and ultimate punish women's anger and desire?	THE
L17	What is the importance of myth, memory, tradition, and place within a Southern context?	THE

Table 11. Literature: Queries of acquaintance about the nature of memory

<i>ID</i>	<i>Question</i>	<i>Form</i>
<i>Memory systems</i>		
CE4	What is the behavior of the buffer-on-board memory system? What is the optimal use of the resources involved?	GOAL
CE12	How should several flavors of memory and logic implementation be realized, considering the versatility and scope of nanoscale devices, in particular the memristor, when employed in different nanoelectronic and hybrid CMOS/Nano circuits?	GOAL
CE15	What hybrid DRAM-PCM memory systems for servers provide robust and consistent memory performance without sacrificing energy?	GOAL
CE18	What are the key bottlenecks to efficiency in the memory system?	GOAL

<i>Memory technologies</i>		
CE1	What memory architecture mitigates the drawbacks of NAND SSDs (slow random write performance) while leveraging their performance advantages (excellent read write latency)?	GOAL
CE2	How can designers build memory allocation policies to efficiently manage the distributed on-chip memory resources at a high level?	GOAL
CE3	How can transactional support be provided for fast, non-volatile memories that exploits their raw performance and makes programming easy? (2) Whether performance improves.	GOAL
CE9	What are the possible approaches to designing and analyzing robust low voltage SRAM?	GOAL
CE10	What are reliable, low-power methodologies for SRAM memories?	GOAL
CE11	(1a) What are the undesirable design traits of DRAM? (1b) How can their effects be mitigated?	GOAL
CE16	What approach should be taken to dynamically set supply voltages and refresh cycle for Dynamic Random Access Memory (DRAM) and 1T1C embedded Dynamic Random Access Memory (eDRAM) in order to reduce power consumption?	GOAL
CE17	What are various angles on optimizing the on-chip memory of embedded systems to improve performance without increasing power consumption or die area?	GOAL
CE19	How can the spatiotemporal interactions in LLC capacity management be exploited to improve CMP's performance?	GOAL
CE20	How can PCM memory, given its long write latency, high write power and limited write endurance, be successfully applied?	GOAL
<i>Memory models</i>		
CE5	What algorithm can effectively enforce stricter memory models in parallel processors, such as the sequentially consistent memory model?	GOAL
CE6	What dynamic optimization techniques, driven by models of shared data and cache use, can be developed for disparate layers of the memory hierarchy?	GOAL
CE7	What model of cache memory can be developed that eliminates context switch misses?	GOAL
CE8	What is an efficient alternative model to existing coherence mechanisms that facilitates the transfer of semantic information from software to hardware and still maintains shared memory?	GOAL
<i>Memory circuits</i>		
CE14	How should logic circuits and their signal representations be configured in order to allow low power, nonvolatile dense memory and logic with minimal connections to CMOS?	GOAL

Table 12. Computer engineering: Queries of rationale/explication about memory optimizations

CE13	Whether the atomic locomotion movements in a virtual reality system with a semi-natural locomotion interface require a user's spatial cognitive resources (working memory).	HYP
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Table 13. Not computer engineering: Query of biconditionality about the effect of  $B$  on memory

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