THE EFFECTS OF EYE GAZE ON MEMORY ENCODING

By

DILLON MILLER

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Written under the direction of

Dr. Robrecht van der Wel

And approved by

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Dr. Robrecht van der Wel

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Dr. William Whitlow

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Dr. Sarah Allred

Camden, New Jersey

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THESIS ABSTRACT

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By: Dillon Miller

Thesis Director:
Dr. Robrecht van der Wel

The purpose of the present research is to further explore the relationship between social cues and memory. In particular, the influence of eye gaze on memory was examined. This is of interest because previous work has established a link between gaze cues and attention. Here, we take this a step further and examine whether memory is also impacted by eye gaze. Participants remembered word lists presented on a computer monitor. These words were presented against a background of a human face looking away from them, looking at them, or looking at them with closed eyes. By doing so, we tested how memory was affected by its embedding in a social context. The results indicate that direct gaze increases memory performance over averted gaze when tested through a recognition test. For recall, memory instead was best for words presented on a face with closed eyes. Thus, social context differentially affects memory for different depths of processing. These results are important because they further the literature for the effects of social cues on memory processing.

Introduction

Eye gaze forms an important cue in social interaction and communication (Csibra & Gergely, 2009; Richardson & Dale, 2005), and people are known to be drawn by direct gaze. For example, when giving a test it becomes readily apparent to an instructor that a student is looking up from their paper because they may have a question (or are trying to cheat). Much research has been conducted on the interaction between social cues and attention, as well as on the interaction between attention and memory. In more mundane settings, gaze direction also plays a central role in communication and social interaction (Peters et. al., 2005), and tends to attract attention (Böckler, van der Wel, & Welsh, 2014).

With respect to the link between attention capture and gaze, Böckler, van der Wel, and Welsh (2014) asked participants to identify one of two possible letters that appeared on one of four faces on a screen. Half of the faces presented started with direct gaze while the other half presented averted gaze. After a set time, one of the faces in each gaze condition switched to the other gaze condition to facilitate a non-social cue. Participants were tested on the speed to report the letter which was used to indicate the capacity to attract and capture attention. The study found that participant reacted faster to the direct gaze conditions as a social cue with sudden direct gaze producing the quickest results. The effect that was found suggests that the social cue of direct gaze significantly attracts attention better than the social cue of averted gaze.

Researchers have also begun to investigate the relationship between social cues and memory. For example, several studies have examined the effect of direct versus averted gaze on the memorability of faces. In these studies, participants viewed a number of faces with either direct or averted gaze. Afterwards, they were then asked to indicate whether they had seen a certain face before or not. The results of these studies indicated that faces with direct gaze were more easily recognized (Hood et. al., 2003; Mason, Hood, & Macrae, 2004). In another task, it was also found that greater listening comprehension was found when eye contact was closely coupled with a speaker's (Richardson & Dale, 2005). In another line of work, Eskenazi et. al. (2013) found that joint task performance modulates memory encoding when the task is relevant to a co-actor, further emphasizing the effects of social influence on memory. These kinds of results together suggest that social cues may influence memory. It is important to note however that the relationship with respect to gaze is still debated. For example, Zhu et al. (2014) argued based on heightened physiological arousal that excessive eye contact impedes memory in a recognition task. Based on the previous literature, it seems likely that memory is affected by social cues. To date, the majority of the research conducted has focused on person memory and auditory memory. It is still unclear whether eye gaze also modulates the ability to encode and remember written information. Here, we seek to explore this possibility.

To gain a more complete understanding of the effects of social cues on memory, we tested memory using two methods: recall and recognition tasks. In this way, we investigated the depth of processing that is affected by social cues. Although both test memory, research has shown that the two tasks operate on different depths of processing (Craik & Tulving, 1975; Balota & Neely, 1980). Flexser and Tulvin (1978) proposed that recall and recognition function on independent retrieval processes. Recall processes were found to require more effort than recognition processes (Craik & McDowd, 1987).

In the present experiment, we tested the effects that social cues have on memory for written words. Our primary hypothesis proposes a mediating relationship between eye gaze as a social cue, and memory. To address this hypothesis, we used three conditions concerning eye gaze; direct gaze, averted gaze, and eyes closed. We also used two memory tests; recall and recognition. Doing so allowed us to examine the effect of social context on different depths of processing.

The effect of social context on differing depths of processing has been shown in the works of Hood et. al. (2002) in that there is a different effect on shallow processing depending on gaze direction. Faces with direct gaze were more recognizable than faces with averted gaze (Hood et. al., 2002). Research has also found that when people want to recall the answer to more difficult questions, they deliberately avert their gaze from others as a way to disengage from their environment allowing for greater resource distribution to recall (Glenberg et. al., 1998). The contrast between the two studies highlights our hypothesis in that shallow processing is enhanced by direct gaze, but deeper processing causes people to avert their gaze.

We hypothesize that the participants in the direct gaze condition will remember the most words correctly while they will remember fewest words in the averted gaze condition.

Method

Participants

Participants were undergraduate students from Rutgers University-Camden who were enrolled in the introduction to Psychology course. Participants were drawn from this population as a sample of convenience given their geographical proximity to the lab and affiliation with the University. We collected a total of 60 participants (46 females, 14 males, mean age = 20.85) in accordance to the replication standard developed by Simonsohn (2015) based on the replication of Eskenazi et. al. (2013) which had collected data from 24 participants.

Materials

In a given trial, participants were seated in a chair situated at a table facing a computer monitor running a MATLAB program. A chin rest was used to ensure head position and comfort. The face displayed was a female face, identical to the face used in Böckler et al (2015). The face was presented in three conditions in randomized order. The “direct gaze” condition displayed the face is looking directly outwards towards the participant. The “averted gaze” condition displayed the face looking away with eyes looking away as well. The “eyes closed” condition, which served as a control condition, displayed the face looking directly at the participant, but with the eyes closed. According to Böckler, van der Wel, and Welsh (2015), direct gaze with eyes closed does not significantly capture attention. Therefore, the lack of effect made this condition suitable as a control condition. Participants were exposed to each condition once for each memory test type for a total of 6 trials. The 6 total trials used each word list once and were ordered through a Latin square algorithm. With the possible ordering sequences set, the exposure to a selected order of word lists was randomized.

We used a total of 6 word lists (Appendix A) that were combined with 3 distractor lists (Appendix B). While the order of the lists per trial was randomized in their exposure, the order within the word lists remained static and appeared as they do in the appendices. The distractor lists were designed to present incorrect words in the recognition task rather than present only the designated words. The words from which the word lists were established were collected from a previously validated word bank used by Eskenazi et. al. (2013). The lists were assembled by random selection and balanced to bring the list letter means to acceptable range (Overall M = 6.51).

We tested memory using recall tasks and recognition tasks. The recall task consisted of a blank sheet of lined paper which participants used to list words they could recall. The recall task was scored based on the number of words listed that corresponded to the designated word list with errors consisting of words that were not associated with the designated list. The recognition task consisted of a sheet containing words from both the designated list and a selected distractor list. The words were placed in alphabetical order to dissolve any ordering issues. The recognition task was scored based on the number of words marked that corresponded to the designated list with errors consisting of marked words that were not associated with the designated list. A script was produced to determine the order of exposure for the word lists, memory tasks, and experimental condition.

Procedure

Before the experiment began, we led the participant to a clear desk and presented the participants with two forms for them to complete: an informed consent form and a handedness survey. When both forms were completed the participant was led to the appropriate desk. Participants were instructed on their task and were provided with a detailed instruction form. Participants were allowed to ask questions if need be. Participants were instructed to place their chin in the designated chinrest at the beginning of each trial. Participants were instructed to look at the screen which showed a black background with a fixation cross in the center after initial setup. After 500 milliseconds, a face appeared showing one of the three experimental conditions (eyes direct, eyes averted, eyes closed) and remained for another 500 milliseconds. At the end of the 500 milliseconds with only the face, a word appeared above the eyes at approximately eyebrow level of the face where we believe the eyes will be drawn to without covering the eyes of the face on the screen. 2000 milliseconds after the presentation of the word on the face, the entire image disappeared, leaving another blank screen. This constituted one instance of a word presentation and this sequence continued until all 20 words for the particular condition were presented.

After 20 total instances, the experiment paused. A prompt appeared on the screen specific to the memory task which asked participants to either write down as many words as they can remember (recall task) or to mark down as many words as they can remember (recognition task). The experimenter then administered the designated task paper. Participants were allowed two minutes to complete the given task to the best of their abilities. After the two minutes expired, the paper was collected and the participant moved onto the next trial. This continued until a total of six trials with each experimental condition were tested with both memory tasks. At the completion of the sixth and final trial, participants were thanked for their contribution and debriefed.

Results

To analyze the data, we conducted a 2 (Memory Measure: recognition, recall) x 3 (Gaze Condition: direct, averted, and closed eyes) repeated measures ANOVA on the performance data and error rates. The assumption of sphericity was not violated for either of these analyses.

Figure 2 displays the results for the performance data. The results of the analysis indicated a main effect of Memory Measure, $F(1, 59) = 579.87$, $p < .01$, indicating that participants performed much better on the recognition task ($M = 14.28$, $SE = 0.30$) than on the recall task ($M = 6.21$, $SE = 0.22$). Interestingly, this main effect was qualified by an interaction with Gaze Condition, $F(2, 118) = 5.28$, $p < .01$.

For the recognition measure, participants performed best for the direct gaze condition ($M = 14.97$, $SE = 0.36$). They performed less well for the averted gaze condition ($M = 14.27$, $SE = 0.44$) and worst for the closed eyes condition ($M = 13.60$, $SE = 0.47$). Post-hoc comparisons revealed a significant difference between direct gaze and closed eyes, $t(59) = .014$, but not between the other conditions.

We computed d prime (d’) for a comparison of hit rates and error rates for the recognition task in all experimental conditions. Figure 3 shows the results for our d’ prime analysis. The direct gaze condition produced d’ = 2.22. The averted gaze condition produced d’ = 203. The closed eyes condition produced d’ = 1.95.

For the recall measure, participants performed best for the closed eyes condition ($M = 6.67$, $SE = 0.28$). They performed less well for both the direct gaze ($M = 6.00$, $SE = 0.36$) and the averted gaze ($M = 5.95$, $SE = 0.28$) conditions. Post-hoc comparisons revealed a trend for the closed eyes condition to differ from the direct gaze ($t(59) = 1.96$, *p* = .055) and the averted gaze ($t(59) = 1.98$, $p = .053$) conditions. Direct gaze did not differ significantly from averted gaze.

To examine potential differences in error rates across conditions, we performed another repeated-measures ANOVA. This analysis did not indicate any significant effects ($p > .05$). Table 1 shows the means and standard errors per condition.

Discussion

In the current study, we tested the effect of the social cue of eye gaze on memory performance in a recognition and recall task. We predicted that direct gaze would facilitate better memory encoding over averted gaze using two separate methods of testing: recall and recognition tasks. The recognition results show direct gaze significantly facilitating memory over averted gaze and closed eyes. The recall results show closed eyes significantly facilitating memory over direct gaze and averted gaze. Direct gaze did not significantly facilitate memory over averted gaze. The results support our hypothesis in that the direct gaze condition significantly facilitated performance in memory recognition over the averted gaze condition.

The results indicate that while direct gaze facilitated recognition, the same cannot be said for the recall task. This result may thus indicate that the effects of social cues differentially affect depths of processing. Both Craik and Tulving (1975) and Balota and Neely (1980) describe the two memory test types as functioning on different levels, which is supported by our findings. Following this line of investigation, we can theorize that direct gaze from another person may impact attention of an observer at a relatively shallow depth of processing. At deeper levels, attention capture may not significantly help memory and may actually be detrimental. In the task of recall, the control condition of closed eyes produced improved memory compared to both open eyed conditions. This finding may suggest that gaze interferes with deeper processing, as attention capture may leave fewer resources to properly encode information (Craik & McDowd, 1987) at deeper levels.

Another way to look at the results is through the work of McCrae et. al. (2003), which found that faces were recognized as a whole structure rather than the sum of its parts through top-down processing. It is possible that when participants are exposed to a word in a given trial, the word on the face becomes part of the facial structure when encoded into memory. Rather than only recognizing the word, people recognize the context of the word (i.e. the word on the face). In following this logic, Hood et. al. (2002) found that faces were more easily recognizable when displaying direct gaze as opposed to averted gaze. The findings of both McCrae et. al. (2003) and Hood et. al. (2002) converge with our own findings. Assuming that the word on the face becomes part of the face during encoding, then the word becomes more easily recognized as part of a face that displays direct gaze rather than averted gaze. This effect does not work for recall. Given the increased resources required for recall over recognition, it stands to reason that breaking the face down into individual parts to get at the word would hinder retrieval by adding additional cost to the process on top of the increased effort over recognition.

Imagine a passenger in a car on a highway. On the highway there are billboards advertising something with a big face with the product name on the face. This big face grasps their attention, but the car is moving too fast to commit the name to memory. In the brief moment when the passenger sees the advertisement, they may not remember the word on the forehead, but they can recognize it when they are in the store. The word cannot be recalled, but it can be recognized.

Limitations

One factor that we did not account for is the potential effect of the white/black balance between the iris of the face and the face itself. This contrast could influence attention instead of the proposed reasoning of the social cue in that the difference in light level between direct gaze, averted gaze, and closed eyes could differentially draw attention. It is unlikely that such differences could account for the interaction of gaze direction and memory measure however

Initially, we had devised to use a control condition that implemented a face with eyes closed which was found to not significantly attract attention (Böckler, van der Wel, & Welsh, 2015). To our knowledge, the eyes closed condition has not been quantitatively tested before to the degree to establish the condition as an appropriate baseline. Future research could examine the effect of closed eyes on memory by comparing it to a condition in which words are presented on a blank screen for example.

Future Research

One possible avenue to further this line of investigation would be to test participants with closed eyes against participants viewing a face with direct gaze condition with verbal testing. The results show that eyes open conditions attract attention and subsequently increase memory performance, but can be disruptive to memory on deeper levels of processing. The participants with closed eyes are ideal to determine the effect of social cues on deeper levels of memory.

There is also the possibility of testing the influence of ethnicity and biological sex of the social cue. For this experiment, we used a Caucasian female face. A logical next step would be to test if there is a difference between male faces and female faces or to test if there is a difference when the ethnicity is different.

Conclusion

Overall, the current study contributes to our knowledge by providing further support for the notion that social cues interact with memory systems. The study also establishes a potential depth to which social cues affect memory performance. We suggest that if you want to truly remember what someone says; you should close your eyes. Looking at them actually hinders depth of encoding, our results suggest.

Appendices

Appendix A

list one	list two	list three	list four	list five	list six
celery	cheetah	earmuffs	Eagle	lamp	groundhog
zucchini	radish	dish	cantaloupe	donkey	ruler
lion	cow	coconut	Bluejay	frog	sheep
dishwasher	pheasant	dresser	bookcase	cabbage	corkscrew
lemon	cucumber	honeydew	apple	clock	tomato
banana	crocodile	kumquat	giraffe	coyote	pillow
pony	onions	goose	avocado	beans	zebra
skateboard	mandarin	leopard	cougar	cranberry	strainer
crayon	toad	beetroot	nectarine	duck	mug
saucer	orangutan	gorilla	ladle	turtle	tortoise
dove	starfruit	bike	cushion	peas	doorknob
panther	couch	elephant	grapefruit	skunk	hare
peppers	screwdriver	blackberry	drapes	strawberry	artichoke
squash	okra	napkin	cat	papaya	blender
oven	faucet	broccoli	racquet	rabbit	rooster
seagull	peach	moose	corn	toaster	orange
rat	wrench	hammer	prune	raspberry	spatula
blueberry	pelican	turkey	spinach	mittens	slingshot
ashtray	jar	pan	pineapple	salamander	elk
swimsuit	hamster	potato	pigeon	tangerine	rhubarb

Appendix B

list one supplement	list two supplement	list three supplement
carrot	lettuce	owl
camel	ox	cherry
grater	pickle	colander
eggplant	sofa	fan
beaver	fridge	grape
grasshopper	raccoon	thimble
microwave	chipmunk	canary
plum	penguin	alligator
comb	shelves	porcupine
walrus	kiwifruit	typewriter
yam	pumpkin	broom
pliers	stool	squirrel
tongs	gopher	kettle
chimp	scissors	cupboard
pomegranite	cauliflower	stove
turnip	buffalo	pear
mushroom	mango	pig
freezer	stereo	paintbrush
spoon	parakeet	sandpaper
hyena	plantain	dolphin

Figure Captions

Figure 1. The left panel shows an example of a sequence of word presentation. The panels on the right show the additional gaze conditions.

Figure 2. Mean hit rates (i.e., mean number of correctly recalled or recognized words out of 20 total words) per condition.

Figure 3. d’ values for recognition per condition

Figure 1


2000 milliseconds
lamp
500 milliseconds
500 milliseconds
Averted Gaze
Eyes Closed

Figure 2

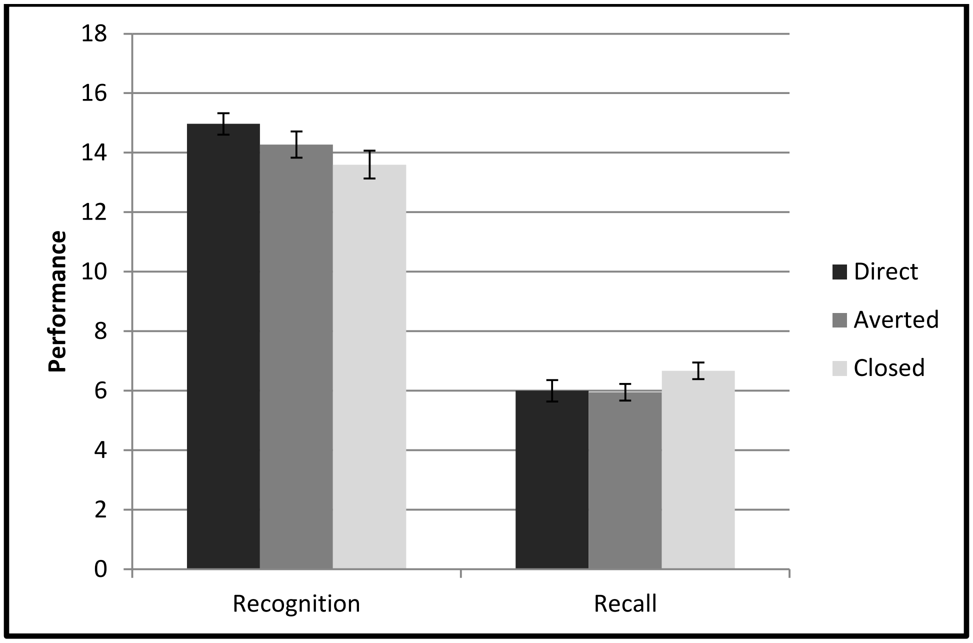
18
16
14
12
10
8
6
4
2
0
Performance
Recognition
Recall
Direct
Averted
Closed

Figure 3

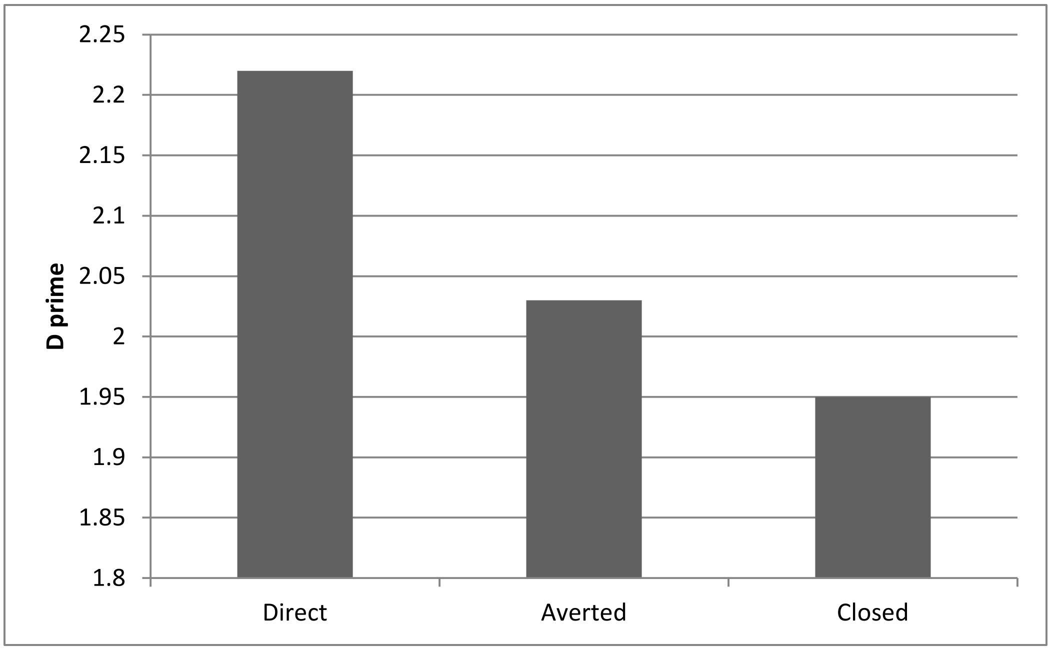

Table 1

	Direct Gaze	Averted Gaze	Closed Eyes
False Recognition	5.6%	7.3%	7.3%
Recall Intrustions	1.23	1.05	0.9

Table 1. Mean number of errors per condition. For false recognitions, these are expressed as a percentage of the total number of distractor items (20). For recall intrusions, these are absolute values.

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