RU STRESSED? THE PHYSICAL AND PSYCHOLOGICAL EFFECTS OF ODOR EXPOSURE AND WRITING ABOUT STRESSFUL EXPERIENCES

by

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ABSTRACT OF THE DISSERTATION

The physical and psychological effects of odor exposure on writing about stressful experiences

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People are constantly exposed to sources of stress. Stress has been shown to affect physical and psychological health. Recent research has demonstrated that writing about stressful events can improve physical and psychological health. Another line of research has shown that odors can have a calming effect and can influence emotions and the way people think and write. This study compared the effects of expressive writing alone and expressive writing with odor exposure on the cognitive and emotional content of narratives about stressful aspects of college life, as well as on physical and psychological health. One hundred and twenty participants were randomly assigned to one of three treatment conditions: One group wrote about neutral topics, the second group wrote about a stressful aspect of their academic life, and the third group also wrote about a stressful aspect of their academic life but was exposed to an ambient room odor while writing. Results showed that exposure to odors may facilitate emotional expression while writing about stressful events, may improve moods, and provide long-term benefits.
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Introduction

Although we are all familiar with the term stress as it is commonly used, stress has been defined by theorists in different ways: as an environmental stimulus, as a physical response, and as an interaction between environmental stimulus and the person (Brannon & Feist, 2007). Different theories have been proposed to explain stress. A popular view proposed by Lazarus (1993) is that the interpretation of the stressful event is more important than the event itself; more specifically, he proposes that the effect that stress has on a person is based more on that person’s feelings of threat, vulnerability, and ability to cope than on the event itself. Thus, any method used to assess stress levels needs to be able to include not only the events themselves but people’s appraisal of the events as stressful.

People are constantly exposed to stimuli which can be classified as stressful; sources of stress can range from daily hassles such as heavy traffic and overpopulation to cataclysmic events. Because stressful stimuli are all around us, it is important to understand how stress affects our physical and psychological health, and what factors influence or minimize the effects of stress, particularly because it has been repeatedly suggested that there is a relationship between stress and decreased immune function (Segerstrom & Miller, 2004). Although such relationship has been more commonly observed when the source of stress is chronic and uncontrollable, even short-term stress has been shown to produce changes in immunity; for instance, Kiecolt-Glaser, Malarkey, Cacciopo & Glaser (1994) studied a sample of medical students and found an increase in disease symptoms before and after exams. In a later study, Kiecolt-Glaser and colleagues found that students who received a wound during exam times took longer to heal than
those who received the same wound during vacation time, once again showing the relationship between stress and immune function (Kiecolt-Glaser, McGuire, Robles, and Glaser, 2002).

To minimize the detrimental effects of stress, people use different coping strategies; these have been categorized into strategies which are oriented towards tackling the source of stress, or problem-focused coping strategies, and strategies which are oriented towards managing the emotions associated with the stressful event, or emotion-focused coping strategies (Folkman & Lazarus, 1980). Although Lazarus has warned about separating and contrasting each other because these strategies presumably supplement each other and “operate as a single coping unit” (Lazarus, 2000), research has shown that use of problem-focused coping strategies is generally related to physical and psychological health (Brannon & Feist, 2007).
Expressive Writing and Stress

A coping strategy which may combine both problem-focused or emotion-focused features depending on how it is used, and which has been found to produce improvements in physical and psychological health, is written emotional disclosure, or expressive writing (EW). For many years, Pennebaker and his colleagues have examined the notion that talking or writing about traumatic or stressful experiences improves both physical and psychological health (e.g. Pennebaker & Beall, 1986; Pennebaker, Colder & Sharp, 1990; Pennebaker, 1997; Pennebaker and Graybeal, 2001). The paradigm used involves asking people in the experimental group to write about their deepest thoughts and feelings related to a traumatic or stressful event, while a control group writes about superficial everyday events, such as how they use their time. Compared to the control group, those who write about traumatic events show improvements in a variety of physical and psychological health measures, such as a reduction in health complaints and visits to the doctor, and improvements in immune function (Pennebaker, Kiecolt-Glaser, & Glaser, 1988). Improvements in behavior have also been reported, such as improved academic performance (Pennebaker & Francis, 1996), and quicker reemployment after job loss (Spera, Buhrfeind, & Pennebaker, 1994).

Numerous studies have been conducted to test the effects of EW on different physical and psychological health measures. Using different populations (e.g. college students, prisoners, caregivers) varying in demographic variables, personality variables, physical health and mental status, these studies have consistently replicated the beneficial effects of EW, although some manipulations seem to be more effective than others, such as offering privacy to participants instead of having them write in a large classroom in the
presence of other participants. Overall, it is well-established that written emotional disclosure or EW is effective and beneficial to physical and psychological health as well as overall functioning, as reported by 3 meta-analyses conducted in the area (Frisina, Borod, & Lepore, 2004; Smith, 1998; Frattaroli, 2006).

Although the original EW paradigm (Pennebaker & Beall, 1986) required participants to write once a day for 15 minutes for 4 consecutive days, later studies have manipulated both the length of the session as well as the spacing between sessions, ranging from once a day for 3-4 consecutive days, to once or twice a week for several weeks (see review in Frattaroli, 2006). Because the beneficial effects of EW have been consistently replicated using such a wide array of parameters, it is still unclear what constitutes the “right” protocol for EW. A question that has recently been examined is: What is the minimum time requirement for the writing schedule? A recent study (Chung & Pennebaker, 2008) compared the effects of the traditional EW paradigm to other variations in spacing between sessions, or 1) writing once a day for 3 consecutive days, 2) writing once per hour for 3 hours with a 35-minute break between sessions, and 3) writing three times in one hour with a 10-minute break between sessions. It is important to note that whereas the spacing between sessions varied, the length of the writing sessions remained the same across conditions (15 minutes). Although participants in the 3 times/1-hour condition described the experience as being more emotionally demanding and exhausting compared to those in the other two EW conditions, and participants in the 3-day condition tended to find the writing assignment “less aversive, and easier to do” (p. 18), the study was a success: There was a reduction in self-reported physical symptoms and visits to the doctor 1 month and 9 months after the study for participants in the
experimental groups but not the control group. In addition, narratives in all three EW conditions contained more emotional and cognitive words than those in the control condition, and that there was no difference in these language features between experimental conditions. Although only self-reported measures of health effects were collected in this study, the results seem to suggest that the beneficial effects of EW may be obtained in a shorter period of time than was originally believed.

Several theories have been proposed to explain the benefits of EW. One of the earliest explanations, Inhibition Theory, was derived from the Freudian concept of catharsis, and proposed that expression of inhibited thoughts and feelings leads to stress reduction and subsequent improvements in physical and psychological health. Several studies have provided evidence against Inhibition Theory; for instance, Greenberg and Stone (1992) found no difference between participants who wrote about previously undisclosed versus previously disclosed traumas, showing that an expression of inhibited thoughts and feelings was not essential to obtain the benefits of EW. Furthermore, writing about an imaginary trauma was found to be as beneficial as writing about a real trauma (Greenberg, Wortman & Stone, 1996). Thus, there is more to emotional disclosure than mere expression of inhibited thoughts and feelings. Another theory that has been proposed is Self-regulation Theory; it has been hypothesized that any task that helps the process of self-regulation should benefit the individual. King (2002) defines self-regulation in terms of goal-attainment; people experience emotions as a result of the status of their goals; when a trauma occurs, it “might muddy the waters of affective feedback” (as cited in Frattaroli, 2006). In this view, EW is beneficial because it allows the person to make sense of the event, explore and take control over their emotions,
clarify their goals, and restore the self-regulation system. This theory would explain why writing about an imaginary trauma would be helpful as it allows people to experience the event and the emotions associated with it, and to take control over them. Similarly, writing about one’s “best possible self” (writing about one’s life as if all one’s goals had been met and everything went as planned) resulted in similar benefits to the traditional EW paradigm, such as a reduction in clinic visits and improved psychological well-being (King 2001), suggesting that getting in touch with one’s goals and taking control over one’s life, even if hypothetically, may be producing the benefits.

Pennebaker and colleagues have proposed a Cognitive-Processing Theory, arguing that the benefits of the EW paradigm are due to cognitive changes associated with writing; on follow-ups, participants who benefited from the study have reported feeling that writing about the traumatic event was beneficial because it helped them to gain insight into their trauma (Pennebaker, Colder & Sharp, 1990). After developing the Linguistic Inquiry and Word Count (LIWC) program (Pennebaker, Francis, & Booth, 2001), Pennebaker and colleagues were able to examine participants’ narratives, rather than relying solely on participants’ self-reports. According to them, participants who write expressively about an event undergo cognitive changes that are reflected on their narratives in their usage of certain features of narrative. Using LIWC, they have determined that the use of “cognitive” words, particularly those associated with causality and insight (e.g. *cause, realize, understand*) often predict whether or not a participant will benefit from writing about a traumatic or stressful event (Pennebaker, 2001). To test the cognitive-processing theory, Kovac and Range (2002) manipulated participant instructions to either encourage cognitive change by explicitly asking them to reinterpret
the traumatic event they were writing about, or facilitate exposure by asking them to “include more and more details about the event” (p. 432). They found that the use of causality and insight words increased over days of writing, and there was no significant difference between the groups in their use of these words. One interpretation of these results is that the act of writing itself encourages cognitive change regardless of instructions received. This is not surprising; the act of creating a story by putting events, feelings and thoughts into narrative form requires that this be coherent, meaning among other things, that it should follow a structural configuration involving time, intention, goal, causality, and sometimes closure (McAdams, 2006). Ironically, by failing to find differences between groups to support the role of cognitive change, Kovac and Range provide evidence for the cognitive function of expressive writing; although participants may begin by focusing mostly on the emotional impact of their trauma, as they continue to think about and write about the event they move towards a resolution or closure. Writing may accelerate or facilitate the coping process by allowing the person to examine the event in a structured format that requires causality, and may naturally lead to insight as one seeks closure. To what extent this natural progress of events is due to self-regulation or cognitive processing, or whether both combine to cause the effect needs to be further investigated.

Other features of narratives that have been associated with the benefits of EW are the use of both positive and negative emotion words, and the use of pronouns. One would expect that asking people to write about upsetting or traumatic events will result in a narrative filled with negative emotion words and few, if any, positive emotion words. Can one benefit from a mere release of negative emotions? After all, it is not uncommon
to hear people talk about “letting it all out” and “venting.” Nonetheless, as useful as the release of negative emotion may be purported to be, that alone may not be sufficient to obtain the full benefits of EW; the quality and the form of the release makes a difference. For instance, rumination involves “engaging in behaviors and thoughts that passively focus attention on one’s symptoms of distress and on all the possible causes and consequences of these symptoms” (Nolen-Hoeksema & Jackson, 2001, p. 37); therefore, even if the ruminating person focuses his/her attention on emotions and causes/consequences of these, this is carried out in a passive manner, such as worrying about how one’s moods may interfere with one’s job but not doing anything to change this, such as seeking support. Rumination is a maladaptive behavior; it promotes cognitive inflexibility and supports depressive symptoms (Sloan, Marx, Epstein, & Dobbs, 2008). On the other hand, expressive writing, although repetitive in nature like rumination, involves more than passively thinking or writing about one’s negative affect.

Pennebaker and Seagal (1999) have reported that participants who obtain maximal benefits from EW show a gradual change in the words they use over the days of writing, resulting in a high number of positive emotion words, a moderate number of negative emotion words, and increased use of cognitive words by the end of the intervention; this suggests that participants are thinking about their traumas differently, and this is reflected on their writing. It could even be said that rumination is the opposite of expressive writing because through rumination one focuses on one’s negative affect and the problems associated with it, while attention is shifted away from potentially adaptive responses such as rational problem-solving (Lyubomisky & Nolen-Hoeksema, 1995), whereas EW promotes taking a more “cognitive” approach to emotions and one’s
problems. In fact, a recent study showed that ruminators can benefit from expressive writing; engaging in this activity resulted in decreased severity of depressive symptoms, and this improvement persisted for 6 months (Sloan, Marx, Epstein, Dobbs, 2008). One of the explanations that are proposed is that the benefits of expressive writing are due to participants being guided to confront their negative thoughts and feelings, to engage in more constructive problem-solving, and finally to restructure their maladaptive cognitions. Thus, the benefits of writing about an upsetting experience may be attributed to more than a mere release of negative emotions, but possibly to the construction of a causal framework under which one can re-evaluate the experience and possibly find solutions. This is consistent with Lazarus’ argument that “stress, coping, and emotion [are] dependent on the relational meaning that an individual person constructs from the person-environment relationship” (Lazarus, 2000, p. 670). As meaning and coherence are created out of the stressful or traumatic event, this can be resolved or forgotten, thereby reducing the maladaptive effects of incomplete processing on health.
Effects of odors on stress, emotions, and cognition

A different line of research exploring alternative ways to minimize the detrimental effects of stress has focused on the effect of odors, showing that odors can have a calming effect. For example, newborn infants exposed to odors of lavender or milk during a stressful event (blood sample taken by heelstick) displayed decreased levels of salivary cortisol compared to those infants who were not exposed to any odors, indicating that they were less stressed by the procedure (Kawakami, Kawakami, Okazaki, Kurihara, Shimizu, and Yanaihara, 1997). Similarly, Lehrner, Marwinski, Lehr, Johren and Deecke (2005) found that dental patients exposed to ambient odors of orange and lavender in the waiting room reported having a lower level of state anxiety, a more positive mood, and a higher level of calmness compared to those who were exposed to music or no stimuli at all. Lavender has also been examined as a tool to improve alertness and mood in participants performing mental tasks such as math problems. This study found that participants reported being more relaxed after smelling lavender and that they performed computations faster compared to before odor exposure (Field, Diego, Hernandez-Reif, Cisneros, Feijo, Vera, Gil, Grina & Claire He, 2005). Similarly, participants exposed to odor of lavender made fewer errors in mathematical and letter counting tasks than those exposed to the odor of jasmine or no odors (Degel & Köster, 1999). Lavender is commonly known as a calming or sedative odor; therefore, researchers proposed that it facilitated performance on the tasks by decreasing the arousal and stress associated with finding oneself in a test situation. Another odor which has been found to have a calming/inhibitory effect is rose. While it could be argued that this effect of odors may be mediated via cognitive mechanisms in humans, researchers have
explored the putative effects of essential oils on animals. Of particular interest to the present study is the finding that the smell of rose oil has been found to have anxiolytic and anti-conflict effects (Umezu, 1999; Umezu, Ito, Nagano, Yamakoshi, Oouchi, Sakaniwa & Morita, 2002), as shown by paradigms used to evaluate anti-anxiety drugs, in which, if the treatment is effective, the animal chooses to receive a reinforcer even when accompanied by punishment as well as other commonly-used paradigms such as exploring the elevated plus maze (e.g. De Almeida, Motta, Faturi, Catallani, Leite, 2004). Furthermore, the anxiolytic effect of rose odor has been found to potentiate or strengthen during prolonged exposure (Bradley, Starkey, Brown & Lea, 2007). Some other investigations have found effects of both implicit and explicit odor exposure on mood and cognition. For instance, Chebat and Michon (2003) found that mall shoppers’ mood was enhanced when they were exposed to an ambient citrus odor, Baron (1990) found that subjects exposed to pleasant odors set higher goals for themselves on a clerical coding task and adopted more efficient strategies for performing the task compared to those not exposed to an odor, while implicit exposure to the odor of citrus-scented all-purpose cleaner facilitated participants’ performance in a cleaning-related word recognition task and resulted in higher frequency of cleaning-related activities while describing their plans for the day (Holland and Henriks, 2005).

Recent research conducted in our laboratory has investigated the effects of implicitly presented odors on the emotional content of memory narratives. Participants were asked to write different narratives, such as a childhood memory, a recent memory, and a recurring dream, while exposed to an ambient room odor. Narrative content analysis using the LIWC program (Pennebaker, Francis, & Booth, 2001) showed that
exposure to odors affected the amount and type of emotion reported differently by gender, type of odor, and type of memory. Specifically, we found that exposure to pleasant odors in general, and perfumes in particular, increased the percentage of positive emotion words and decreased the percentage of negative emotion words used by male participants in dream recall narratives. The opposite effects were found for women: exposure to odors decreased the percentage of positive emotion words and increased the percentage of negative emotion words reported in dream narratives. In a later investigation, participants were asked to spray their pillowcase with one of five pleasant odors and were asked to keep a dream diary for a week. Results showed that participants who were exposed to the smell of rose during sleep used a higher percentage of positive emotion words in their dream reports compared to those exposed to no odor or one of the other pleasant odors (Castellanos & Hudson, manuscript in preparation).

In addition to the effects of odors on emotional content of narratives, we have also examined the effects of odors on the cognitive features of narratives; specifically, by comparing the frequency of cognitive words used by participants exposed to different types of odors and those not exposed to an odor. No significant effects of odor were found on percentage of cognitive words used in narratives in the autobiographical memory investigation, possibly because participants wrote about their memories only one time; length of days of writing appears to be an important factor in producing cognitive changes in language (Pennebaker, 1997). Interestingly, in the dream diary study in which participants wrote down their dreams over several days, even though they were different dreams every night, we found an odor by gender interaction effect on percentage of cognitive words used; specifically, men who were exposed to the smell of lavender
reported a higher percentage of cognitive-related words than did women or men exposed to no odor or other pleasant odors

Taken together, these studies suggest that odors can have a significant effect on the way people feel and think; they can influence emotions and emotional content of memory narratives, probably as a result of the direct synapsing from the olfactory area to the amygdala and hippocampus, important for the regulation of emotions and for emotional memory respectively (Cahill, Babinsky, Markowitsch, & McGaugh, 1995; Herz, Eliassen, Beland & Souza, 2004), and they can influence cognition, although that connection may not be a direct one. Besides decreasing the effects of negative affective states, odors may exert their effects on cognition is through the induction of positive affect. For instance, Higuchi and colleagues (2005) found that applying perfume to young female participants, midway through an interview, resulted in self-reported improvement in mood, including an increase in self-reported dominance and relaxation, as well as a decrease in movements indicative of nervousness or anxiety (i.e. fidgeting). Similarly, exposure to a variety of colognes and perfumes, including some described as having “floral” notes resulted in a positive change in mood for both male and female participants, compared to baseline measures of mood, and to the mood of participants in the control condition (Schiffman, Sattely-Miller, Suggs, and Graham, 1995; Schiffman, Suggs, Sattely-Miller, 1995). The effects of pleasant and unpleasant odors can lead to positive and negative affective states respectively (Ehrlichman & Halpern, 1988), which has also been shown in the different patterns of electrophysiological activation produced by pleasant and unpleasant odors (e.g. Alaoui-Ismaïli, Vernet-Maury, Dittmar, Delhomme, & Chanel, 1997; Bensafi, Rouby, Farget, Bertrand, Vigouroux, & Holley,
2002); specifically, odors that are rated as pleasant induce mainly reports of, and physiological activation associated with, happiness and surprise whereas odors rated as unpleasant evoke mainly patterns associated with anger and/or disgust (Alaoui-Ismaili, Robin, Dittmar and Vernet-Maury, 1997). Pleasant odors can induce positive emotions which, in turn, can facilitate cognitive processing.
Positive emotion and cognition

The effects of positive emotions on cognition and on cognitive processing have been widely studied. Isen and her colleagues have shown in an extensive number of studies that positive affect influences cognition (see Isen 2000 for review). They have induced positive affect in the laboratory using a wide range of stimuli such as showing funny films or cartoons, giving small gifts, and offering positive feedback, among many others. Their results have consistently shown that people in whom positive affect was induced are more creative than controls or more able to solve problems requiring ingenuity or innovation (e.g. Estrada, Isen & Young, 1994), more efficient in reaching decisions (Isen & Means, 1983), and more efficient in negotiating to obtain better outcomes (Carnevale & Isen, 1996). Overall, positive emotions have been found to increase cognitive flexibility, creativity, motivation and to facilitate adaptive thinking in problem solving and decision-making (Isen, 2002), not necessarily by increasing global motivation, but by fostering different approaches to situations, sometimes setting preferences for certain behaviors, and in some cases by increasing intrinsic motivation (Isen, 2002).

What could account for this facilitative effect of positive affect? After all, it has often been proposed that positive emotions cause “superficial, lazy, inattentive processing, and [to] interfere with careful, effortful, effective thought and problem solving” (Isen 2002, p57). However, the broaden-and-build model of positive emotion posits that positive emotions broaden the individual’s attentional focus and behavioral repertoire, and as a consequence, build their social, intellectual, and physical resources (Fredrickson, 1998). Fredrickson reviews the work of Isen among many others, to offer
empirical support for this model. The evidence supports the notion that positive affect facilitates cognition, and Fredrickson further proposes that positive affect can promote the creation of a durable set of personal resources that can be used not only at the time that the emotions are experienced, but also at later times and in different contexts. Positive emotions can “restore flexible thinking following lingering negative emotional experiences” (Fredrickson, 1998, p. 314), this facilitates the use of adaptive coping strategies (Folkman & Moskowitz, 2000) and promotes well-being and health, and may underlie the beneficial effects of clinical interventions (Fredrickson, 2000).

Exercise training is a health behavior which people can voluntarily choose to engage in, but it has also been used as a clinical intervention because of its positive effect on emotions. Thus, it is not surprising that it may also have an effect on cognition. A meta-analysis (Lander & Arent, 2007) found evidence to indicate that exercise training can improve mood, reduce anxiety and depression, improve cognitive function, and may even facilitate the use of coping strategies or protect against stress by serving as an “inoculator” (p. 483). Not only has exercise been attributed with improving mood and cognition, but only overall psychological well-being (Cramer, Nieman, & Lee, 1991; Byme & Byme, 1993; Brown, Wang, Ward, Ebbeling, Fortlage, Puleo, Benson & Rippe, 1995; Tomporowski, 2003). Thus, a study examining connections between stress, moods, and cognition, needs to take into consideration participants’ physical activity levels.
Goals of the present study

The study of the effects of odors on narrative construction has shown interesting results; however, participants in our studies have been restricted to the type of narrative they should report (e.g. childhood memory, dream report, etc), while they have been free to report narratives with the emotional valence of their choice (negative, positive or neutral); if we were to test the stability of odor effects, it seems more reasonable to examine the effects described using one type of narrative (recent event) with one type of emotional valence (negative). Thus, the first goal of the study was to examine the effects of odor exposure on narratives about stressful experiences; more specifically, about experiences of an academic nature that the participant perceives as stressful.

Another goal was to explore whether odors support or facilitate the cognitive processes which have been proposed by Pennebaker and colleagues as mediators in the physical and psychological benefits of expressive writing. If pleasant odors induce positive affect, and positive affect promotes cognitive flexibility, it follows that odors should facilitate cognitive processing. Thus, one of the goals of the proposed study was to examine the effects of odor exposure on outcome measures, as well as on language features of narratives about a stressful experience to determine whether these differ between participants who write while exposed to an odor and those not exposed to an odor. Given the trends and effects found in research conducted in our laboratory, and on the results from the odor and positive affect research areas, I expected to find differences in outcome measures and on the usage of cognitive and emotion-related words in narratives of participants exposed to odors compared to those not exposed to odors.
Further, considering the findings of past research on the calming effects of odors and their ability to elicit positive emotions, another goal was to determine whether participants exposed to odors will report a higher degree of psychological well-being and more positive moods than those not exposed to odors. Since research on the effects of odors on moods has been limited to using lavender or other similar essential oils popular in aromatherapy, another goal was to examine whether other pleasant odors can influence self-reported moods and emotional narrative content. Because of the increased use of positive emotion words in participants exposed to the smell of rose in our dream diary study, this odor stimulus is a good candidate for the proposed study.

Finally, considering the connection between exercise, moods and cognition, another goal was to examine the relationship between participants’ exercise levels and their moods, and to determine whether this relationship extends to emotional and cognitive-related words used to describe their stressful experiences.
Design

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
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<tbody>
<tr>
<td>Expressive Writing – No Odor</td>
<td>Expressive Writing – Odor</td>
<td>Control Writing – No Odor</td>
</tr>
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Hypotheses

H1: Exposure to odors will increase the cognitive and emotional content of narratives compared to narratives of participants not exposed to odors (Group 2 highest).

H2: Exposure to odors and expressive writing will result in improved self-reported mood, psychological well-being, and physical health at the end of the experiment compared to the control group which will not be exposed to odors or engage in EW (Groups 1 and 2 higher than Group 3).

H3: Participants’ physical activity level will correlate positively with self-reported mood as well as cognitive and emotional content of narratives.
Method

Participants

Participants were 120 students (60 males, 60 females) recruited from the Rutgers University undergraduate participant pool and through campus advertisements. Because smoking may affect olfactory acuity, only nonsmokers were recruited. The mean age of participants was 18.6 years (range: 18 to 26 years). 47% of participants described themselves as White, 27% as Asian, 12% as Black, 10% as Hispanic/Latino, and 4% as Other. Participants recruited from the undergraduate participant pool fulfilled requirements for their General Psychology course and received research credits for their participation. Participants recruited through campus advertisements were paid $20. Because the study pertained to stress related to academic life, data collection was delayed until the week of midterm exams (Mid October) to allow for students to be exposed to academic stress. Data collection took place in one semester and it was timed to ensure that all those participating for research credit received their credit by the conclusion of the semester.

Design and Treatment conditions

Forty participants (20 males, 20 females) were randomly assigned to one of three treatment conditions: Expressive Writing – No Odor (Standard Pennebaker experimental group), Expressive Writing – With Rose odor exposure (Combined experimental group), and Control Writing – No Odor (Standard Pennebaker control group).
Measures and Tasks

1. **Undergraduate Stress Questionnaire (USQ)**

Participants who are higher in stress benefit more from experimental disclosure (Frattaroli, 2006); thus, stress levels were measured using the USQ. This stress inventory provides a list of sources of stress commonly affecting college students. Participants were asked to check off the situations that they had experienced during the past two months. Because the same event may be interpreted differently depending on the individual, a modified version of the USQ included a line for participant ratings of the level of stress caused by each situation. This task helped to assess the stress levels that they had been recently exposed to and to provide a stress score, and it was administered during the initial interview.

2. **Satisfaction with Life Scale (SWLS)**

Participants who engage in expressive writing improve in measures of subjective well-being. Subjective well-being was measured in the present study using the SWLS, a 5-item questionnaire developed by Ed Diener and colleagues (1985) to measure life satisfaction, a factor in the general construct of subjective well-being. The items are measured using a 7-point Likert scale ranging from 1 = strongly disagree to 7 = strongly agree. The five items are all keyed in a positive direction, so the five responses can simply be added to arrive at a total score for the scale. The possible range of scores is therefore 5 to 35, with a score of 20 representing the neutral point on the scale. Scores between 5 and 9 indicate that the respondent is extremely dissatisfied with life, whereas scores ranging between 31 and 35 indicate that the respondent is extremely satisfied with life. Scores between 21 and 25 represent slightly satisfied, and scores from 15 to 19 are
interpreted as falling in the slightly dissatisfied range. This scale was administered during the initial interview, during the weekly follow-up, and during the monthly follow-up.

3. **Differential Emotions Scale (DES)**

   Developed by Izard, the DES Short-Form measures 10 discrete emotions: joy, surprise, sadness, anger, disgust, contempt, fear, shame/shyness, and guilt. Each emotion is rated on a multipoint scale for how the subject currently feels. Responses can range from 0 = not at all to 7 = extremely. This scale was administered during the initial interview, during the weekly follow-up, and during the monthly follow-up.

4. **Pennebaker Inventory of Limbic Languidness (PILL)**

   A 54-item scale developed by Pennebaker (1982) to measure the frequency of a group of common physical symptoms and sensations, the PILL is one of the physical health outcome measures commonly used in EW studies. Typically, participants use a scale ranging from 1 to 5 to indicate the frequency in which they experienced each symptom/sensation in the previous month, ranging from 1 = have never or almost never experienced to 5 = more than once every week. In the present study, symptoms were presented as a checklist because the focus was on presence of symptoms rather than their frequency, and also to make the initial and final interviews as quick as possible. The PILL was administered during the initial interview and during the monthly follow-up.

5. **International Physical Activity Questionnaire (IPAQ)**

   The IPAQ is a valid and reliable questionnaire developed by an international group of physical assessment experts to measure health-related physical activity. The short version asks about frequency and time spent in 4 generic forms of physical activity, which are applicable to a college population. It has been determined that this version of
the IPAQ is suitable to use with young and middle-aged adults. Questionnaire was obtained from IPAQ website, http://www.ipaq.ki.se, and was administered during the initial interview, during the weekly follow-up, and during the monthly follow-up.

6. Narrative Task

Participants in the EW groups were asked to write about a stressful event associated with their academic life and to write about it with as much detail as possible, including emotional impact. Participants in the control group were asked to describe behaviors or actions of different days (yesterday, today, and tomorrow) without mention of emotions. Participants were asked to write about their assigned topics for 3 sessions of 15 minutes each. All writing sessions took place on the same day, with 10-min inter-session break. Chung & Pennebaker (2008) showed that it was feasible to conduct all writing sessions over the course of approximately 65 minutes and obtain results comparable to those of the traditional 3-consecutive-days paradigm; furthermore, the 3-sessions-in-65-min paradigm was expected to maximize participant compliance and reduce dropout rates compared to the traditional paradigm.

Stimuli and Experimental Room Preparation

Participants in the Odor condition were exposed to the smell of Rose. The odor stimulus was provided by International Flavors and Fragrances (Union Beach, NJ) and was calibrated to peri-threshold (just below detection) exposure levels. Non-fragranced polyethylene pellets were placed in jars containing the odor until the pellet completely absorbed the oil. Before placing the pellet on a small metal tray where it remained for the experimental session, the experimenter dabbed any excess fragrance oil on a paper towel
once using a plastic forceps. Separate forceps were used for each odor condition. A small fan oscillated in close proximity to the stimulus tray to distribute odorant throughout the room. The experimental rooms were kept shut so that they would fill up with the odor.

After ten minutes, the experimenter returned to the experimental room and opened the windows slightly. The door of the experimental room was kept ajar and a large fan at the highest speed was turned on in the open space for five minutes to evacuate the initial alcohol odor noticed during intensity testing. The door and windows were then closed and a participant was allowed to enter the experimental room. Participants were unaware of the preparation of the experimental room. After the experiment was complete and the participant exited the room, the experimenter removed the odor pellet, discarded it in a waste area, and repeated the procedure used to air-out the room before the experiment began. After five minutes, the experimenter repeated the entire procedure with a fresh odor pellet provided that another participant was scheduled for that day.
Procedure

During the initial interview, the experimenter read the consent form to participants, highlighting important points. After signing the consent form, participants were directed to a computer on which they provided demographic information and completed a set of questionnaires (USQ, DES, SWLS, PILL, and IPAQ). Upon completion, participants were escorted individually into a separate experimental room which, depending on treatment condition assigned, had or had not been treated with the odor stimulus. They were then asked to write about their assigned topics by typing their narratives into a computer. Participants were allotted 15 minutes to complete their narrative because this is the time allotted in most emotional disclosure studies.

Instructions for the narratives were as follows:

Expressive Writing condition

(Session 1) In this part of the experiment, I want you to think and write about an event or aspect of your academic life which has been particularly stressful to you (e.g. failing important exams or missing important deadlines, adjusting to the various aspects of college life, or even about your feelings of who you are and what you want to become). I want you to let go and write about your very deepest thoughts and feelings surrounding this experience. The important thing is that you really dig down to your very deepest emotions and thoughts and explore them in your writing. All information you provide will be kept confidential. Please continue to write until I come back.

(Session 2) In this part of the experiment, I want you to think and write about the event or aspect of your academic life which has been particularly stressful to you, and which you wrote about in the first writing session. You may write about general issues or about more specific ones regarding how this event or experience affects you. The important thing is that you really dig down to your very deepest emotions and thoughts and explore them in your writing. Again, all information you provide will be kept confidential. Should you finish writing about this event before the time expires, please try to keep writing. Please continue to write until I come back.

(Session 3). In this part of the experiment, I want you to think and write about the event or aspect of your academic life which has been particularly stressful to you,
and which you wrote about in the first two writing sessions. Even when we think we have said everything about an event, there are always more thoughts or feelings we can talk about. You may write about general issues or about more specific ones regarding how this event or experience affects you. The important thing is that you really dig down to your very deepest emotions and thoughts and explore them in your writing. Again, all information you provide will be kept confidential. Should you finish writing about this event before the time expires, please try to keep writing. Please continue to write until I come back.

**Control Writing Condition** (Same instructions for all 3 sessions)

In this part of the experiment, I want you to describe in detail what you [did/have done/will do] [yesterday/today/tomorrow] since you [woke/will wake up] in the morning until you [went/will go] to bed at night. It is important that you describe things exactly as they [occurred/expect they will occur]. Please do not just list the events; we need you to write in paragraph form using whole sentences. It is important that you do not mention your own emotions, feelings, or opinions; your description should be as objective as possible. Please continue to write until I come back.

After each set of instructions, the experimenter set a timer for 15 minutes, left the room, and returned when the timer went off. Narratives were saved on the computer, and participants were given instructions to engage on an unrelated task until it was time for their next writing session (10 minutes). After the first distracter task, participants were given instructions for the second writing session, and were asked to write about it for another 15 minutes. Once again, narratives were saved on the computer, and participants engaged in another unrelated task for the duration of their break (10 minutes). At the end of the second break, participants were given instructions for the third writing session. Once again, narratives were saved on the computer, and participants completed the post-writing questionnaires (DES) and rated different features of the experimental room (lighting, temperature, odors) for pleasantness/intensity. The experimenter made sure that no participants were distraught or upset before leaving, answered any general questions, and asked participants not to talk to other participants about the details of the study.
Participants were also reminded that they would be contacted via e-mail 1 week and 1 month later with a link to some questionnaires they needed to complete (DES, SWLS, and PILL). Only 9 participants did not complete the monthly follow-up; one was (woman) in the Control group, 4 (2 men, 2 women) were in the EW No Odor group, and 4 (2 men, 2 women) were in the EW Rose group.

Narrative Content Coding

All narratives were analyzed using the Linguistic Inquiry and Word Count (LIWC) program. Cognitive content was measured as the percentage of all words in a narrative that refer to a cognitive word. Three measures of cognitive content were analyzed: Total percentage of cognitive words, percentage of causality words, and percentage of insight words. Emotional content was measured as the percentage of all words in a narrative that refer to an emotion. Five measures of emotional content were analyzed: Percentage of positive emotion words, percentage of negative emotion words, and the percentages of three specific negative emotions: Hostility words, sadness words, and anxiety words.
Results

*Environmental Questionnaire*

A 2(Gender) x 3(Experimental Condition) Analysis of Variance conducted for effects of odor exposure on participants’ ratings of odor pleasantness revealed no significant effects, $F(2, 110) = 2.44; \text{n.s.}$ These results indicated that the room odor did not stand out as particularly pleasant compared to the conditions in which no odor was presented. Participants therefore did not detect the presence of odor in the room.

*Undergraduate Stress Questionnaire (USQ)*

Scores ranged from 16 to 220. Mean USQ score was 81.82, with a standard deviation of 39.36. The frequency distribution of scores is shown in Figure 1. A 2(Gender) x 3(Experimental Condition) ANOVA revealed a Condition x Gender interaction, $F(2, 112) = 5.08; p<.01$. Women in the Control and EW Rose conditions scored higher than did men in those conditions, while women in the EW No Odor group scored lower than did men.

*H1: Exposure to odors will increase the cognitive and emotional content of narratives compared to narratives of participants not exposed to odors.*

To test this hypothesis, a 3(Writing session) x 3(Condition: Control, EW No Odor, EW Rose) x 2(Gender) Analysis of Variance with repeated measures for Writing Session was conducted on all measures of cognitive and emotional content. Narratives were analyzed separately by positive emotions, negative emotions, different types of negative
emotions (anger, sadness, anxiety), and different types of cognitive-related processes (insight and causality). Any significant interaction effects were followed by Tukey post-hoc tests.

Main effects of Condition were found for all measures of cognitive and emotional content and indicated that participants used fewer cognitive and emotion words altogether, and for each category of emotion, in the Control condition than in the two EW conditions. Differences between the two EW conditions were not significant. These data are shown in Table 1.

Main effects of Writing Session were found for percentage of positive emotion words, $F(2, 224) = 5.19; p<.01$ ($\eta_p^2 = .044$), for sadness related words, $F(2, 224) = 4.22; p<.05$ ($\eta_p^2 = .036$), for total cognitive words, $F(2, 224) = 18.42; p<.01$ ($\eta_p^2 = .141$), and for causality-related words, $F(2, 224) = 4.61; p<.01$ ($\eta_p^2 = .040$). As far as emotional content is concerned, participants used significantly more positive emotion words in the third writing session ($M = 2.45, SD = 1.48$) than in the first ($M = 2.05, SD = 1.20$) or second ($M = 2.15, SD = 1.37$) sessions, and they used fewer sadness-related words in the third writing session ($M = 0.34, SD = 0.55$) than in the first ($M = 0.43, SD = 0.53$) or second ($M = 0.51, SD = 0.74$) sessions. As far as cognitive content is concerned, participants’ use of cognitive-related words significantly increased across writing sessions (First session: $M = 16.42, SD = 4.30$; Second session: $M = 17.32, SD = 4.35$; Third session: $M = 18.47, SD = 4.56$), and they used significantly more causality words during the second ($M = 2.02, SD = 1.18$) than during the first ($M = 1.78, SD = 1.05$) or third ($M = 1.70, SD = 1.14$) writing sessions. In addition, a Writing Session x Condition interaction was found for insight-related words, $F(4, 224) = 3.65; p<.01$ ($\eta_p^2 = .061$), as
well as a Writing Session x Condition x Gender interaction for causality-related words, $F(4, 224) = 2.68; p<.05$ ($\eta_p^2 = .046$). As shown in Figure 2, participants in both EW conditions used more insight-related words in all sessions than those in the Control condition, and while participants in both EW conditions used almost identical percentage of insight-related words in Sessions 1 and 2, those in the EW Rose condition used a higher percentage in Session 3 compared to those in the EW No Odor condition. As shown in Figure 3, women in both EW conditions show an increase in the use of causality-related words from Session 1 to Session 2, followed by a decrease in Session 3. Men in the EW No Odor condition follow a similar, though not as pronounced, pattern as their female counterparts, while men in the EW Rose condition show a decrease in causality-related words from Session 1 to Session 2, followed by an increase in Session 3. Female participants use more causality-related words than men in Session 2, while male participants use more causality-related words than women in Session 3.

Main effects of Gender were found for anger-related words, $F(1, 112) = 4.88; p<.05$ ($\eta_p^2 = .023$), and for total cognitive words, $F(1, 112) = 5.19; p<.01$ ($\eta_p^2 = .044$). Female participants used significantly more anger words ($M = 0.34, SD = 0.51$) and more cognitive words ($M = 17.79, SD = 4.32$) than did male participants, ($M = 0.25, SD = 0.39$) and ($M = 16.96, SD = 4.61$) respectively. Furthermore, a marginal Condition x Gender interaction effect was found for anger words, $F(2, 112) = 2.41; p = .07$. These data are shown in Table 2. To further explore the gender differences found, the data file was split by gender, and pair-wise comparisons were conducted among the experimental groups. Results showed that female participants in the EW Rose condition used significantly more anger-related words in their narratives ($M = 0.57, SD = 0.68$) than did those in the
EW No Odor ($M = 0.36$, $SD = 0.46$) or Control conditions ($M = 0.10$, $SD = 0.19$). This pattern was not found among male participants. These data are shown in Figure 4.

Thus, results show that use of positive emotion and cognitive words increased over time while use of negative emotion words decreased over time. The only group differences that were found were a result of time and not due to being exposed to an odor, except for the use of anger-related words but only among women, or the greater use of insight-related words by the EW Rose group in Session 3.

**H2: Exposure to odors and expressive writing will result in improvement in self-reported moods, psychological well-being, and physical health**

To test this hypothesis, Analysis of Variance (ANOVA) tests were conducted for measures of mood (Differential Emotions Scale), psychological well-being (Satisfaction with Life Scale) and physical health (Pennebaker Inventory of Limbic Languidness) by time and condition.

**Differential Emotions Scale (DES).** Separate 3(Condition: Control, EW No Odor, EW Rose) x 4(Time: Baseline, Immediate post-test, 1-Week follow-up, 1-Month follow-up) x 2 (Gender) ANOVA were conducted for the emotions that matched the variables analyzed in the content analysis (i.e. happiness, fear, anger, anxiety, sadness).

Preliminary analyses of baseline scores on these measures indicated Condition effects on baseline measures of sadness [$F(2, 112) = 3.03; p = .05$ ($\eta_p^2 = .051$)], fear [$F(2, 112) = 3.03; p = .05$ ($\eta_p^2 = .051$)] and anxiety [$F(2, 112) = 3.89; p < .05$ ($\eta_p^2 = .044$)]; therefore, the ANOVAs for these measures were run with baseline scores for each as covariates. A main effect of Time was found for self-reported happiness [$F(3, 297) = 5.02; p < .01$ ($\eta_p^2 = .048$)], fear [$F(2, 194) = 4.16; p < .05$ ($\eta_p^2 = .04$)], anger [$F(3, 297) = 2.58; p = .05$ ($\eta_p^2 = .048$)].
anxiety \[ F(2, 197) = 5.74; p < .01 (\eta^2_p = .055) \], and sadness \[ F(2, 197) = 7.74; p < .01 (\eta^2_p = .073) \]. As shown in Table 3 and in Figures 5-10, participants reported a significant decrease in happiness, fear, anger, anxiety and sadness from baseline to immediate post-test, and these levels were significantly lower than those reported at 1-week or 1-month follow-up, except in the case of anxiety in which levels reported at 1-month follow-up were at comparable (low) levels.

Main effects of Condition were found for fear: \[ F(2, 98) = 4.85; p < .01 (\eta^2_p = .091) \]. Participants reported higher levels of fear in the EW No Odor (\( M = 1.14, SD = 1.30 \)) than in the Control (\( M = 0.71, SD = 1.06 \)) or EW Rose condition (\( M = 0.47, SD = 0.88 \)), though only the difference between the two EW groups was significant.

Significant Time by Condition interaction effects were found for happiness: \[ F(6, 297) = 2.43; p < .05 \]. These data are shown in Table 3, and in Figure 6. While all participants reported a decrease in happiness immediately upon completing the study tasks compared to baseline levels, those in both EW groups reported an increase at follow-ups compared to those in the Control group who continued to report similar (low) levels.

*Satisfaction with Life Scale (SWLS)*. A 3(Condition: Control, EW No Odor, EW Rose) x 3(Time: Baseline, 1-Week follow-up, 1-Month follow-up) x 2(Gender) ANOVA was conducted. As described in the Methods, the possible range of scores for this scale is 5 to 35, with a score of 20 representing the neutral point on the scale. Scores between 5 and 9 indicate that the respondent is extremely dissatisfied with life, whereas scores ranging between 31 and 35 indicate that the respondent is extremely satisfied with life.
Scores between 21 and 25 represent slightly satisfied, and scores from 15 to 19 are interpreted as falling in the slightly dissatisfied range. For the summed aggregate score of all 5 items, there was a main effect of Time, $F(2, 208) = 4.79; p<.01$. Participants reported a significantly higher satisfaction score at 1-week follow-up ($M = 22.13, SD = 6.53$) than at baseline ($M = 20.82, SD = 6.48$), but not significantly different from 1-month follow-up ($M = 21.47, SD = 7.21$). Thus, participants reported higher life satisfaction scores at follow-up, indicating higher satisfaction with life, or subjective well-being, at follow-up compared to baseline. No gender or condition main effects or interaction effects were found.

_Pennebaker Inventory of Lambic Languidness (PILL)._ A 3(Condition: Control, EW No Odor, EW Rose) x 2(Time: Baseline, 1-Month follow-up) x 2 (Gender) ANOVA was conducted. There was a main effect of Time for number of physical symptoms: $F(1, 105) = 14.15; p<.01$, number of visits to the doctor: $F(1, 105) = 6.53; p<.01$, and number of days spent sick: $F(1, 105) = 14.47; p<.01$. Participants reported significantly fewer physical symptoms at one-month follow-up ($M = 12.86, SD = 8.46$) than at baseline ($M = 15.92, SD = 8.23$). Also, participants reported a significantly higher number of visits to the doctor at baseline ($M = 0.66, SD = 1.40$) than at 1-month follow-up ($M = 0.36, SD = 0.93$). Finally, participants reported a significantly higher number of days sick at baseline ($M = 5.01, SD = 4.88$) than at 1-month follow-up ($M = 3.07, SD = 3.30$).

A main effect of Condition was found for number of days spent sick, $F(1, 105) = 3.49; p<.05$. Participants reported a higher number of days sick in the EW No Odor ($M = 5.02, SD = 3.69$) than in the Control ($M = 3.19, SD = 3.78$) or EW Rose ($M = 3.95, SD = 4.35$) conditions.
Significant Time by Condition interactions were found for number of visits to the doctor: \( F(2, 105) = 4.94; p<.01 \), and number of days spent sick: \( F(2, 105) = 5.17; p<.01 \). These data are shown in Table 4. Participants in the Control condition reported an increase in number of visits to the doctor and number of days spent sick, while participants in both EW groups reported a decrease.

There were no main effects or interaction effects for days restricted due to sickness.

**H3:** Participants’ physical activity level will correlate positively with self-reported mood as well as cognitive and emotional content of narratives

Overall, 48% of participants reported engaging in intense physical activity at least one day a week, 59% reported engaging in moderate physical activity at least one day a week, and 93% reported walking on at least one day a week.

To test the hypothesis that physical activity would correlate with mood and narrative content, Pearson’s correlation coefficients were calculated between mood scale scores and physical activity scores at baseline, 1-week follow-up, and 1-month follow-up. Also, Pearson’s correlation coefficients were calculated between physical activity scores at baseline and mean percentage of cognitive and emotional words. As shown in Table 5, baseline results showed negative correlations between minutes spent doing intense physical activity and self-reported sadness \( (r = -.19; p < .05) \) and self-reported anxiety \( (r = -.21; p < .05) \), as well as a positive correlation between minutes spent sitting and self-reported guilt \( (r = .29; p < .05) \). 1-week follow-up results showed only a positive correlation between number of days on which participant walked and self-reported

surprise ($r = .21; p < .05$). Finally, 1-month follow-up results showed negative correlations between number of days on which participant walked and self-reported anger ($r = -.27; p < .01$), shame ($r = -.25; p < .05$), anxiety ($r = -.23; p < .05$), frustration ($r = -.26; p < .01$) and guilt ($r = -.20; p < .05$).

Regarding the relationship between physical activity levels and narrative content, no correlations were found between days/minutes spent doing intense physical activity, days spent doing moderate physical activity, days/minutes spent walking, or minutes spent sitting, and any of the narrative content variables. However, positive correlations were obtained between minutes spent engaged in moderate physical activity and mean percentage of: total emotion words ($r = .21; p < .05$), negative emotion words ($r = .24; p < .01$), anger-related words ($r = .32; p < .01$), sadness-related words ($r = .27; p < .01$), and a marginal positive correlation with insight-related words ($r = .18; p = .06$).

**Optional Participant Feedback**

At 1-month follow up, participants were asked to provide optional feedback, specifically, “any comments on the experiment or its impact on your life.” 35 participants provided optional feedback. Out of these, 12 were in the control group, 12 in the EW No Odor group and 11 were in the EW Rose group. In the control group, 5 respondents (42%) found the experiment useful; common responses were that it allowed them to organize their plans, and to spread out tasks over several days to minimize the stress associated with having many things to do. 8 participants (67%) in the EW No Odor group found the experience positive; common responses involved expressing or re-evaluating thoughts or feelings, becoming aware of sources of stress, and someone found
it a “useful method for coping with stress.” 10 people (91%) in the EW Odor group found the experiment helpful; common responses involved awareness of stress sources and of personal motivations, evaluation and/or expression of feelings including the ability to express stress “without the usual anxiety that comes with those thoughts”, and of the experience facilitating problem-solving, as in the case of one participant who wrote “after seeing the problem in writing, I was able to come up with a decision I have not regretted.”
Discussion

Hypothesis 1.

The hypothesis that exposure to odors would increase cognitive and emotional content of narratives was partly supported. As expected, and consistent with the results reported by Pennebaker and colleagues, participants in the two expressive writing conditions reported more cognitive and emotional words in their narratives than those in the control condition; however, there was no significant difference in cognitive and emotion-related word usage between those who wrote expressively while exposed to an odor and those who were not exposed to an odor. We found in a previous study (Castellanos et al. 2010) that odors do not uniformly increase use of emotion-related words in narratives; instead, these vary by gender and type of emotion. When all emotions were analyzed separately, no significant difference was found between participants who were exposed to an odor and those not exposed to an odor, except for usage of anger-related words. A very interesting finding was that female participants who were exposed to rose odor while writing expressively used more anger-related words in their narratives than did males in the same condition or females in the other conditions. While research has suggested that women express both positive and negative emotions, including anger, in their conversations and written narratives more often than do men (Brody & Hall, 2004), this gender difference was not found in the other study conditions. Because the percentage of anger-related words used by male participants in the EW Rose condition and that of both male and female participants in the EW No Odor condition are strikingly similar, it seems reasonable to conclude that while men may not spontaneously express anger in the same way that women do, asking them to write about their deepest
thoughts and feelings surrounding a stressful event, and giving them the privacy to do so, could bridge the gender gap that is found under normal circumstances. On the other hand, being exposed to an odor accentuates this gender difference. Considering the parameters of the study, the topics which participants wrote about, and the way in which odor tend to elicit emotional responses, being exposed to an odor in the present study may have facilitated the expression of frustration and anger participants were already feeling; after all, when the 3 writing sessions/1-hour condition has been used in the past (e.g. Chung & Pennebaker, 2009), participants described the experience as being more “emotionally demanding and exhausting” compared to those who have had longer intervals between writing sessions. Most participants in the present study wrote about the frustration associated with the pressures of college life and striving to get good grades; however, others wrote about more intimate, personal details of their life. The frustration associated with both the study paradigm and the writing topics is perfectly illustrated by the narrative of a female participant in the rose condition who wrote:

“I am so frustrated that everything seems to bother me such as writing about this bullsh*t for the third time and that f---ing ticking timer behind me. I am so stressed out that it angers me and I feel like being aggressive because I know I feel like throwing that d*mn timer out the d*mn window… don’t think I am crazy. I am just very tired and I had a long, bad day… I think I failed my psychology test… F**K! If we are not supposed to be cursing and keeping this writing assignment formal, I apologize.”

While few narratives were as explicit as the one excerpted above, and almost no other participants referred to the study environment, as shown by the significant gender by condition interaction, narratives written by female participants in this study condition contained large amounts of profane language, denoting high levels of anger and frustration. Even more interesting is the finding that this gender difference vanished
when participants were asked to rate their mood after the writing task. At that point, the rating for how much anger and frustration they were experiencing was remarkably similar and low (ranging from 0 = “not at all” to 4 = “moderately”) for both genders in both expressive writing conditions. Why would participants report experiencing low levels of anger when they had just finished writing narratives filled with anger words? As we have discussed elsewhere (Castellanos et. al., 2010), self-report is not always a reliable measure, and when it comes to self-report of emotion in studies where olfactory stimuli are presented, it is “fairly common for a self-report to indicate arousal when psychophysiology indices or even behavioral indices indicate relaxation or vice versa” (Haviland-Jones & Wilson, 2005); thus, one cannot discount the possibility that participants may have toned down their reports of negative moods because they wanted to be seen in a positive light, although considering that they typed their narratives and completed the self-reports in a computer, alone in a room instead of being interviewed by the experimenter, this seems highly unlikely. In any case, the present finding is inconsistent with previous studies on expressive writing which have reported an increase in negative moods shortly after writing sessions, reason for which meta-analyses have often excluded studies with follow-ups of less than 1 month (e.g. Smyth, 1998). Not only did participants’ self-ratings of anger not increase, they remained reliably low at 1-week and 1-month follow-up for those in the rose condition compared to those in the other conditions, particularly for female participants, i.e. those who used the highest number of anger-related words in their narratives.

While research on gender differences in the expression of anger have been inconsistent, large-scale surveys have shown that females are able to express as much or
even more anger than males; for instance, a survey of almost 8,000 Icelandic adolescents found that males and females reported comparable levels of anger to negative life events (Sigfusdottir & Silver, 2009), and one of over 6,000 international participants showed that women expressed more anger than men (Brebner, 2003). Thus, the question is not whether women are able to express anger or to report expressing or experiencing anger, but rather, why is there a gender difference in narrative content but not in questionnaire data? While a social roles explanation would offer at least some insight into why women reported low levels of anger on the questionnaire due to traditional social roles and expectations about how women should behave even if they were not directly reporting to the experimenter, it would not explain why women in the rose condition expressed so much anger in their narratives to begin with and why this anger seems to dissipate in the questionnaire. Because the parameters of the present study differ from other expressive writing studies only in that participants were exposed to an odor while writing, one plausible explanation is that, as proposed, exposure to the odor promoted or facilitated emotional expression, which happened to be negative (and angry) in writing because of the topics involved and study parameters. Why is this effect found only in women? If women are capable of expressing as much or more anger than men, being exposed to a stimulus that facilitates emotional expression would result in more intense or higher levels of expression. Why does this anger seemingly dissipate? A recent study found that women are perfectly able to express as much anger as men, the difference is that women use a wider range of anger-coping styles; for instance, they use more assertion, diffusion (e.g. distracting themselves with work, exercise, or even writing about the angering event), or social strategies such as support-seeking (Linden, Hogan, Rutledge, Chawla,
Lenz & Leung, 2003). I propose that the odor stimulus may have also facilitated the use of said coping strategies. It has been suggested that some floral odors (and fine fragrances containing floral notes) may contain “phyto-pheromones” that mimic human pheromones and communicate emotional and social information within the species (Haviland-Jones, Rosario, Wilson & McGuire, 2005). In one study, people who were presented with flowers exhibited social and even sensual responses such as hugging or kissing the person who presented the flower to them. The authors speculate that humans may be sensitive to this floral social chemicals which affect courtship and social behaviors, even when only the odor of the flower is present (Haviland-Jones, Rosario, Wilson & McGuire, 2005).

This is consistent with our finding that participants who were exposed to rose odor used more sexual-reference words and that female participants used more social-reference words (Castellanos & Hudson, manuscript in preparation). Haviland-Jones and colleagues (2005) have proposed that besides affecting moods, odors may work as “search engines,” priming a person to search for specific information; for instance, to search for a “romantic or warm person,” but if “the person is wrong then the search is derailed” (p.23) Because participants had a choice regarding what stressful topic to write about, the odor may have primed them either to be more “social” or “sensual,” to search and write about people who cause stress in their lives and to explore this in their writing, thereby using the writing itself as an anger-diffusion strategy, or to include in their writing those people who help them cope with stress on a daily basis, thereby engaging in support-seeking while writing about their stressors, as illustrated by the following excerpt which is the concluding paragraph of a narrative about a participant’s struggle with getting good grades:
“I know there are a lot of distractions that I can get rid of, but who wants to give up love. I just celebrated my 1 year anniversary with my first serious boyfriend. Yes, I sometimes choose to stay at his house over the weekend instead of studying, but I just look at it as sacrifices that I have to make and then compensate for the lack of studying during the week. Everyone wants to be successful, but everyone needs to be loved.”

Because the odor has primed them to “search” for people, in some cases, the participant may write about the lack of social support they are experiencing, which adds to their stress, such as in the following narrative:

“Classes and Registration makes me depressed right now and my stress reliever is all the way in Florida. My stress reliever is my ex girlfriend and she is my ex because of the long distance between us. I can not handle school and worry about her at the same time, especially when she does not trust me. I need her touch, laughs and inspiring words though… o yea and the SEX!”

Because the study instructions were to write about stressors and not about people who help them cope, participants’ choice to write about people seems to support the “search engine” theory and to show that floral odors elicit social and sensual responses.

On the one hand, the odor may prime participants to be more social or write about people, in which case they may write about those who stress them and their frustration with these individuals, which would explain the high use of anger-related words. On the other hand, they may use anger to describe their stressors but because the odor has primed them to search for people, they write about those who help them cope with stress, or in extreme cases when there is no one to help them cope, the search may get “derailed.”

Alternatively, the instructions themselves may “derail” the search because they require them to write about their academic life when the odor has primed them to search for people, and this incongruency may be expressed as anger and frustration. Nonetheless, because women are capable of using such a wide range of anger-coping strategies, either by thinking and writing about their support systems, by asserting themselves, by
distracting themselves, or by coming up with some solution, they may bring this anger under control. Besides facilitating emotional expression, the odor may then serve another function. As noted in the introduction, exposure to pleasant odors results in enhanced moods (e.g., Ehrlichman & Bastone, 1992; Schiffman, Sattely-Miller, Suggs, and Graham, 1995; Schiffman, Suggs, Sattely-Miller, 1995). In particular, the calming/inhibitory properties of rose odor may have enhanced participants’ moods and allowed them to engage in coping strategies to diffuse or take control over their negative emotions. After all, as upsetting and stressful as it may be to think and write about negative aspects of your life, it has been shown that even people who are experiencing chronic stress can use positive emotions to help them cope with stressors (Folkman & Moskowitz, 2000). This would at least suggest that as predicted, odors facilitate the cognitive processing that seems to be characteristic of expressive writing; the next set of analyses support this notion.

Consistent with Pennebaker’s research, participants’ use of positive emotion and total cognitive-related words progressively increased across writing sessions, while their use of sadness words progressively decreased across writing sessions. This is also consistent with the findings that positive emotions facilitate cognitive processing (review in Isen, 2000). While no main effect of experimental condition was found for these variables, the two-way and three-way interactions that were found for insight- and causality-related words show that exposure to rose odor may have played a role in affecting participants’ cognitive processes. For instance, while the use of insight-related words showed minimal change across writing sessions for all participants who wrote expressively, participants who were exposed to rose odor exhibited the highest usage of
this type of words out of all the narratives, and during the last writing session. It is also
interesting to note that, as shown in Figure 3, female participants who were exposed to
rose odor; i.e. those who expressed the highest percentage of anger in their narratives,
also showed an increase in causality-related words, meaning that even while, or perhaps
due to, expressing their anger, they were still trying to make sense out of the event and
find causal relationships, as proposed by the Cognitive Processing Theory. This
combined with the increased use of positive emotion words across writing sessions, the
high proportion of anger-related words used by female participants in the rose condition
and the mood self-ratings, lends support to the notion that rose odor may not only
facilitate emotional expression but also enhance moods, which in turn may facilitate
cognitive processing.

Exposure to rose odor has been associated with decreases in negative moods and
increases in positive ones. In a previous study, we found that exposure to rose odor
during sleep resulted in a higher proportion of positive emotion words being used to
report dreams from the previous night (Castellanos & Hudson, manuscript under
preparation). It must be noted that, as researchers, we exerted no influence over what
type of dreams participants experienced or reported, meaning that the odor or other
variables may have influenced the nature of the dream. However, this is the first study in
which participants have been exposed to this odor while being asked to write about
particularly upsetting or stressful experiences, so it could be said that we are testing the
buffering effects of exposure to a pleasant odor. It may be difficult for the odor to exert a
positive influence on word usage when such an intensely negative event is being
examined, until we analyze the content of narratives across writing sessions, as well as outcome variables.

**Hypothesis 2.**

The hypothesis that exposure to odors and expressive writing would result in improvement in self-reported moods, psychological well-being, and physical health was partly supported. It has been reported that expressive writing produces negative short-term effects on mood due to the nature of the topics being discussed (e.g. Pennebaker & Seagal, 1999). When we examine self-reported moods, participants in the expressive writing condition who were not exposed to an odor reported higher levels of fear than those who were exposed to rose odor or those in the control condition, which as far as comparison to the control group is concerned, it is consistent with previous findings. It is also interesting to emphasize that the time effects and time by condition interactions that were found show that participants who were exposed to rose odor reported lower levels of anxiety and fear over time compared to those who wrote expressively but were not exposed to an odor. In addition, those in the rose condition reported higher levels of happiness at 1-week follow up, a 0.85-point increase from their post-test score, compared to those who wrote expressively but were not exposed to an odor (0.28-point increase) or those in the control group who actually reported a decrease in level of happiness. At 1-month follow-up, the levels of happiness that were reported were relatively similar for all participants. This suggests that, although short-lived, exposure to rose odor may have enhanced self-reported positive moods, as predicted, either by “buffering” against the effects of the negative moods associated with writing about unpleasant or distressing
events, as noted at 1-month follow-up by a participant in the rose condition who wrote: “I really liked the experiment because it gave me the opportunity to express fully an aspect of my life that really stresses me… I was able to really think about my stress without feeling that usual anxiety that goes along with those thoughts,” or by allowing participants to delve in their emotions but take control over them and immediately return to baseline, as noted by another participant in this condition who wrote: “Writing always helps me to sort out my feelings, so having a chance to write them helped me to understand them so that, while I still worry about the situations, I feel a little better and I know exactly how I feel.”

Regarding psychological well-being as measured by the Satisfaction With Life Scale, the mean scores of study participants’ ratings of well-being fell in the 20-24 range or “average score.” According to Diener (2006), “the average of life satisfaction in economically developed nations is in this range – the majority of people are generally satisfied, but have some areas where they very much would like some improvement” (p.1), so the sample recruited in the present study provides a good representation of the population. Analyzing the summed score of all items showed an increase at follow-up indicating higher satisfaction or psychological well-being. However, there were no condition or interaction effects for this variable, which suggests that study participation was sufficient to improve scores regardless of study condition, perhaps as a result of increased self-awareness, as noted by a participant in the control group: “[The experiment] made me think about how one day, I had a ton of things to do and was really busy, but [for] other days, I barely had anything to write. Maybe if I spread out my tasks over the days, college would be a bit easier.” While participants in the control condition were instructed NOT to focus on emotions when describing the activities of each day, simply putting
these down on paper, may have resulted in self-reflection and awareness of the areas in
their life which needed improvement. For instance, one participant wrote that due to
participation in the experiment s/he came to the following realization: “I need to only be
concerned with my goals, not necessarily satisfying others.”

As far as physical well-being is concerned, results were consistent with
predictions. Overall, all participants reported fewer physical symptoms at 1-month
follow-up compared to baseline. However, only those in both expressive writing
conditions reported decreases in scores for all 4 physical health variables, compared to
those in the control condition whose scores actually increased over time for 2 of the
variables. This is partly consistent with the findings of Pennebaker and colleagues that
expressive writing improves physical health. Furthermore, even though participants in
the expressive writing condition who were not exposed to an odor reported a lower
number of days spent sick at follow-up compared to baseline, this number was higher
than that of participants who were exposed to rose odor. While the findings are based on
participants’ self-reports, which may be influenced by variables such as memory and
motivation, and while a variable such as “number of visits to the doctor” may be
influenced by other variables besides physical health, such as having time or motivation
to go see the doctor, the variable “number of days spent sick” could be seen as
independent of such influences and as a better representative of physical health. Thus,
this finding is consistent with predictions and lends support to the notion that expressive
writing combined with exposure to rose odor would result in further improvements to
physical health compared to expressive writing alone.
Hypothesis 3.

The hypothesis that participants’ physical activity level would correlate positively with self-reported mood as well as cognitive and emotional content of narratives was partly supported. As far as the relationship between physical activity and mood is concerned, baseline results supported the predictions; for instance, as minutes spent engaged in intense physical activity increased, sadness and anxiety scores decreased, and as minutes spent sitting down increased guilt scores increased. In addition, results at 1-month follow up partly supported predictions; they showed that as minutes spent walking increased, self-reported anger, shame, anxiety, frustration and guilt decreased. As far as the relationship between physical activity and narrative content is concerned, results partly supported the hypothesis; they showed that as minutes spent engaged in moderate physical activity as reported at baseline increased, so did the percentage of negative emotion words, anger-related words, sadness-related words, and insight-related words. Conclusions drawn from these results are limited because they are based on self-reports and correlations, but taken together, these results are consistent with the findings that exercise may improve moods, cognition and overall psychological well-being (e.g. Cramer, Nieman, & Lee, 1991; Byme & Byme, 1993; Brown, Wang, Ward, Ebbeling, Fortlage, Puleo, Benson & Rippe, 1995; Tomporowski, 2003). The finding that there was a positive correlation between being engaged in exercise and expressing negative emotion in narratives could be seen as surprising or inconsistent with predictions, unless we were to argue that all forms of emotional expression are healthy and represent good psychological well-being. Considering that the topics which participants wrote about were negative and upsetting, one could argue that expressing innermost feelings and
thought, even if negative, would be in the best interest of the participant, as long as they are able to cope or benefit from this in the long-term. The relationship between physical activity and use of insight-related words points us in this direction.
General conclusion

While some of the findings of the present study are only suggestive, combined with the research on expressive writing, on the effects of odors on emotional expression and social behavior, the effects of positive moods on stress and on cognition, they seem to point us in an interesting direction. The relationship between odors and emotion and cognition is more complex than what some of the previous research has indicated. For instance, a pleasant odor may not instantly turn on a “happy” switch; the context influences the role that the odor will play. The findings of the present suggest that odors do facilitate emotional expression, this may be positive or negative depending on the context, and it may carry long-term benefits. Not only do odors affect our moods/emotions, they make us more social or sensual, influence the types of memories which are remembered and the way in which they are communicated, and may also offer at least short-term protection against the negative effects of stressors by enlisting our cognitive and emotional repertoire. While the effects of expressive writing on physical and psychological health are undeniable, odors may be supporting the processes which expressive writing ignites. Unfortunately, one of the limitations of the present study is the lack of a Control Writing with Rose Odor condition; including a 4th condition would have allowed us to learn more regarding the effects of odor exposure alone on outcome measures. Also, the fact that the baseline and post-test measures were obtained in the laboratory environment, while the two sets of follow-up measures were obtained outside of the laboratory may have contributed to variability that was unrelated to the group assignments.
Another potentially confounding effect was the baseline differences between groups on measures of reported stress and mood. No clear explanation for these differences is apparent. Because the same experimenter both prepared the experimental room with the odor stimulus and conducted the initial interview, one possibility is that the odor may have permeated the experimenter’s clothing and started affecting participants before they arrived at the experimental room. However, this would not explain differences in self-reported mood between the two no odor conditions. Nonetheless, future studies should ensure that different experimenters prepare the odor stimulus and interact with participants to obtain baseline measures. As far as differences in stress level is concerned, perhaps an earlier preliminary screening would have been helpful in order to match participants on stress level. Also, it is possible that we may have obtained stronger effects of odor had participants experienced higher levels of stress. After all, research has found that participants who are higher in stress benefit more from experimental disclosure (Frattaroli, 2006), and the distribution of stress scores in the present study was positively skewed.

Few differences between the two expressive writing groups were significant, either due to sample size, having a sample composed only of college students, because the distribution of stress scores was positively skewed, or because expressive writing alone is sufficient to cause these changes, but the differences that were large enough to be statistically significant point us in this direction. Participants do not report feeling more joy/happiness after writing about their stressors, although there is an increase in their use of positive emotion words across writing sessions. They do report feeling moderate or low levels of negative emotions, even immediately after expressing high amounts of
negative emotion in their writing—and these levels remain low over time, which is different from what previous research has found. Is it not preferable to express yourself very intensely in one session in order to experience subsequent lower levels of negative emotions and to feel better over time? Those who provided feedback at follow-up confided that they found the experiment useful in making them more aware of their feelings and motivations, and in that it gave them tools to combat stress. These tools may or may not translate into behavior; for example, one participant in the rose group reported that participating in the experiment made her think about exercising more.

As we have found in the past, there was a disconnect between participants’ self-reports of mood and their behavioral information. Odors may affect people in a way that they may not even realize. Future studies should combine self-report, behavioral, and physiological measures to get a more complete picture of the human emotional makeup. For instance, the use of physiological measures could help us determine whether the proposed buffering effects of odors can be quantified. Also, a future study could focus only on female participants to determine whether the effect of odor exposure can be replicated and to further explore the notion that odors may be promoting the use of anger-coping strategies.
References


Table 1. Mean Percentages, Standard Deviations, and F-ratios for Emotional and Cognitive Narrative Content.

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>EW No Odor</th>
<th>EW Rose</th>
<th>F-ratio*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive emotion words</td>
<td>1.28 (0.92)</td>
<td>2.81 (1.22)</td>
<td>2.57 (1.58)</td>
<td>55.09</td>
</tr>
<tr>
<td>Negative emotion words</td>
<td>0.42 (0.49)</td>
<td>3.02 (1.45)</td>
<td>2.98 (1.71)</td>
<td>148.45</td>
</tr>
<tr>
<td>Anger words</td>
<td>0.08 (0.17)</td>
<td>0.35 (0.46)</td>
<td>0.45 (0.57)</td>
<td>23.45</td>
</tr>
<tr>
<td>Anxiety words</td>
<td>0.15 (0.24)</td>
<td>1.41 (1.06)</td>
<td>1.38 (1.20)</td>
<td>66.67</td>
</tr>
<tr>
<td>Sadness words</td>
<td>0.07 (0.17)</td>
<td>0.66 (0.70)</td>
<td>0.56 (0.67)</td>
<td>36.97</td>
</tr>
<tr>
<td>Cognitive-related words</td>
<td>13.12 (2.82)</td>
<td>19.70 (3.16)</td>
<td>19.50 (3.74)</td>
<td>161.28</td>
</tr>
<tr>
<td>Insight words</td>
<td>0.40 (0.56)</td>
<td>3.15 (1.28)</td>
<td>3.36 (1.62)</td>
<td>113.98</td>
</tr>
<tr>
<td>Causality words</td>
<td>0.98 (0.70)</td>
<td>2.36 (1.07)</td>
<td>2.18 (0.99)</td>
<td>55.22</td>
</tr>
</tbody>
</table>

*All ratios significant at \( p < .01 \).
Table 2. Mean Percentages and Standard Deviations for Emotional and Cognitive Word Usage by Condition and Gender

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>EW No Odor</th>
<th>EW Rose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total emotion</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1.67 (0.95)</td>
<td>5.99 (1.65)</td>
<td>5.80 (1.90)</td>
</tr>
<tr>
<td>Male</td>
<td>1.76 (1.22)</td>
<td>5.62 (1.59)</td>
<td>5.34 (2.43)</td>
</tr>
<tr>
<td><strong>Positive Emotion</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1.21 (0.81)</td>
<td>2.84 (0.98)</td>
<td>2.63 (1.13)</td>
</tr>
<tr>
<td>Male</td>
<td>1.38 (1.04)</td>
<td>2.78 (1.49)</td>
<td>2.52 (1.58)</td>
</tr>
<tr>
<td><strong>Negative Emotion</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.46 (0.50)</td>
<td>3.17 (1.39)</td>
<td>3.13 (1.77)</td>
</tr>
<tr>
<td>Male</td>
<td>0.38 (0.50)</td>
<td>2.83 (1.53)</td>
<td>2.85 (1.66)</td>
</tr>
<tr>
<td><strong>Anxiety</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.13 (0.20)</td>
<td>1.50 (1.09)</td>
<td>1.34 (1.04)</td>
</tr>
<tr>
<td>Male</td>
<td>0.18 (0.30)</td>
<td>1.30 (1.02)</td>
<td>1.41 (1.34)</td>
</tr>
<tr>
<td><strong>Anger</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.10 (0.19)</td>
<td>0.36 (0.46)</td>
<td>0.57 (0.68)</td>
</tr>
<tr>
<td>Male</td>
<td>0.06 (0.15)</td>
<td>0.34 (0.46)</td>
<td>0.33 (0.42)</td>
</tr>
<tr>
<td><strong>Sadness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.06 (0.16)</td>
<td>0.73 (0.73)</td>
<td>0.63 (0.82)</td>
</tr>
<tr>
<td>Male</td>
<td>0.07 (0.17)</td>
<td>0.58 (0.64)</td>
<td>0.50 (0.49)</td>
</tr>
</tbody>
</table>
Table 3. Mean Ratings and Standard Deviations for Emotions Reported (DES) by Condition and Time.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Post-test</th>
<th>1-Wk Follow-up</th>
<th>1-Mo Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Happiness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>2.05 (0.99)</td>
<td>1.65 (0.75)</td>
<td>1.57 (0.89)</td>
<td>1.73 (1.10)</td>
</tr>
<tr>
<td>EW No Odor</td>
<td>2.03 (1.09)</td>
<td>1.66 (1.09)</td>
<td>1.94 (1.16)</td>
<td>1.83 (1.12)</td>
</tr>
<tr>
<td>EW with Odor</td>
<td>1.73 (1.21)</td>
<td>1.27 (1.03)</td>
<td>2.12 (1.24)</td>
<td>1.79 (1.29)</td>
</tr>
<tr>
<td><strong>Sadness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>1.08 (1.01)</td>
<td>0.47 (0.79)</td>
<td>0.92 (1.04)</td>
<td>1.08 (1.16)</td>
</tr>
<tr>
<td>EW No Odor</td>
<td>1.11 (0.99)</td>
<td>1.23 (1.19)</td>
<td>1.20 (1.08)</td>
<td>1.14 (1.19)</td>
</tr>
<tr>
<td>EW with Odor</td>
<td>0.73 (1.01)</td>
<td>0.79 (1.24)</td>
<td>0.79 (0.89)</td>
<td>0.79 (1.11)</td>
</tr>
<tr>
<td><strong>Anger</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>0.73 (0.93)</td>
<td>0.16 (0.44)</td>
<td>0.76 (0.98)</td>
<td>0.59 (0.76)</td>
</tr>
<tr>
<td>EW No Odor</td>
<td>0.80 (0.96)</td>
<td>0.60 (0.97)</td>
<td>0.91 (1.06)</td>
<td>0.69 (1.02)</td>
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<tr>
<td>EW with Odor</td>
<td>0.39 (0.93)</td>
<td>0.55 (1.09)</td>
<td>0.52 (0.71)</td>
<td>0.48 (0.97)</td>
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<tr>
<td><strong>Fear</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Control</td>
<td>1.19 (1.50)</td>
<td>0.35 (0.75)</td>
<td>0.65 (0.99)</td>
<td>0.65 (1.03)</td>
</tr>
<tr>
<td>EW No Odor</td>
<td>1.11 (1.40)</td>
<td>0.91 (1.19)</td>
<td>1.17 (1.31)</td>
<td>1.37 (1.46)</td>
</tr>
<tr>
<td>EW with Odor</td>
<td>0.31 (0.74)</td>
<td>0.34 (0.74)</td>
<td>0.66 (1.10)</td>
<td>0.56 (0.95)</td>
</tr>
<tr>
<td><strong>Anxiety</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>2.00 (1.33)</td>
<td>1.05 (1.14)</td>
<td>1.58 (1.24)</td>
<td>1.41 (1.42)</td>
</tr>
<tr>
<td>EW No Odor</td>
<td>1.89 (1.43)</td>
<td>1.36 (1.31)</td>
<td>1.97 (1.36)</td>
<td>1.71 (1.40)</td>
</tr>
<tr>
<td>EW with Odor</td>
<td>1.24 (0.99)</td>
<td>1.15 (1.15)</td>
<td>1.39 (1.17)</td>
<td>1.03 (1.10)</td>
</tr>
</tbody>
</table>
Table 4. Mean Ratings and Standard Deviations for Physical Health (PILL) by Time and Condition

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>1-Month Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical symptoms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>16.95 (10.34)</td>
<td>12.95 (6.92)</td>
</tr>
<tr>
<td>EW No Odor</td>
<td>16.44 (4.58)</td>
<td>14.25 (8.83)</td>
</tr>
<tr>
<td>EW with Odor</td>
<td>14.21 (8.55)</td>
<td>11.29 (9.53)</td>
</tr>
<tr>
<td>Doctor visits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>0.21 (0.41)</td>
<td>0.37 (0.99)</td>
</tr>
<tr>
<td>EW No Odor</td>
<td>1.11 (1.98)</td>
<td>0.31 (0.67)</td>
</tr>
<tr>
<td>EW with Odor</td>
<td>0.71 (1.29)</td>
<td>0.38 (1.10)</td>
</tr>
<tr>
<td>Days sick</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>3.05 (3.61)</td>
<td>3.34 (3.97)</td>
</tr>
<tr>
<td>EW No Odor</td>
<td>6.83 (4.75)</td>
<td>3.22 (2.63)</td>
</tr>
<tr>
<td>EW with Odor</td>
<td>5.29 (5.52)</td>
<td>2.62 (3.18)</td>
</tr>
<tr>
<td>Days restricted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>2.21 (4.25)</td>
<td>1.45 (2.98)</td>
</tr>
<tr>
<td>EW No Odor</td>
<td>1.92 (3.67)</td>
<td>1.83 (2.36)</td>
</tr>
<tr>
<td>EW with Odor</td>
<td>2.88 (4.28)</td>
<td>1.38 (2.46)</td>
</tr>
</tbody>
</table>

1 While regression to the mean is a concern in all pretest-posttest comparisons, the presence of a Control group in the present study may minimize this phenomenon.
Table 5. Correlations Between Physical Activity (IPAQ) and Emotions (DES) Reported at Baseline

<table>
<thead>
<tr>
<th></th>
<th>Happ</th>
<th>Inter</th>
<th>Surp</th>
<th>Sad</th>
<th>Ang</th>
<th>Cont</th>
<th>Fear</th>
<th>Shame</th>
<th>Anx</th>
<th>Frust</th>
<th>Guilt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intense Activity</td>
<td>-.04</td>
<td>-.01</td>
<td>.07</td>
<td>.02</td>
<td>.11</td>
<td>.06</td>
<td>.05</td>
<td>.02</td>
<td>-.15</td>
<td>.04</td>
<td>.06</td>
</tr>
<tr>
<td>Intense (min)</td>
<td>-.02</td>
<td>.07</td>
<td>-.01</td>
<td>-</td>
<td>-.15</td>
<td>-.07</td>
<td>-.16</td>
<td>-.01</td>
<td>-</td>
<td>.16</td>
<td>-.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate Activity</td>
<td>-.02</td>
<td>.03</td>
<td>.10</td>
<td>.01</td>
<td>-.01</td>
<td>.06</td>
<td>-.06</td>
<td>.03</td>
<td>-.13</td>
<td>.03</td>
<td>-.03</td>
</tr>
<tr>
<td>Moderate (min)</td>
<td>-.08</td>
<td>-.11</td>
<td>-.03</td>
<td>.01</td>
<td>-.03</td>
<td>-.03</td>
<td>-.05</td>
<td>-.03</td>
<td>-.07</td>
<td>-.11</td>
<td>-.13</td>
</tr>
<tr>
<td>Walking</td>
<td>-.11</td>
<td>-.05</td>
<td>.03</td>
<td>.10</td>
<td>-.11</td>
<td>-.06</td>
<td>-.01</td>
<td>-.04</td>
<td>-.03</td>
<td>-.12</td>
<td>-.15</td>
</tr>
<tr>
<td>Walking (min)</td>
<td>.13</td>
<td>.14</td>
<td>.13</td>
<td>-.07</td>
<td>.11</td>
<td>.05</td>
<td>.11</td>
<td>-.02</td>
<td>.03</td>
<td>-.03</td>
<td></td>
</tr>
<tr>
<td>Sitting</td>
<td>.11</td>
<td>-.13</td>
<td>.09</td>
<td>.13</td>
<td>.01</td>
<td>.04</td>
<td>-.01</td>
<td>.08</td>
<td>-.01</td>
<td>.10</td>
<td>.29*</td>
</tr>
</tbody>
</table>

*p<.05

2 Number of significant correlations, but not pattern, consistent with null hypothesis
Figure 1. Distribution of Undergraduate Stress Questionnaire scores
Figure 2. Mean Percentage of Insight-Related Words by Writing Session and Condition
Figure 3. Mean Percentage of Causality-Related Words by Writing Session, Condition and Gender
Figure 4. Mean Percentage of Anger-Related Words by Gender and Condition
Figure 5. Mean Ratings of Anger (DES) by Time, Condition and Gender
Figure 6. Mean Ratings of Happiness (DES) by Condition and Time
Figure 7. Mean Ratings of Sadness (DES) by Condition and Time
Figure 8. Mean Ratings of Anger (DES) by Condition and Time
Figure 9. Mean Ratings of Fear (DES) by Condition and Time
Figure 10. Mean Ratings of Anxiety (DES) by Time and Condition
Appendix

Demographic and Academic Information Form

Gender: (check one)       _____ Female       _____ Male

Age: ________

Ethnicity: (check one)

       _____White/Caucasian       _____Black/African American
       _____Hispanic/Latino       _____Asian       _____Native American
       _____Other (specify) ________________________

Year in college: ________

How many credits are you taking this semester? ________

List the courses you are currently enrolled in and estimate your grade in each at this point:

________________________________________
________________________________________
________________________________________
________________________________________
________________________________________
________________________________________
________________________________________
**Undergraduate Stress Questionnaire**

Below is a list of stressful events commonly affecting college students. Please circle the number next to any events that have affected you in the last 2 weeks. If you check off an event, please rate how stressful it was, using the following scale:

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Not stressful at all</strong></td>
<td><strong>Moderately stressful</strong></td>
<td><strong>Extremely stressful</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Death (family member or friend) ______
2. Had a lot of tests ______
3. Applying to graduate school ______
4. Victim of a crime ______
5. Assignments in all classes due the same day ______
6. Breaking up with boy/girlfriend ______
7. Found out boy/girlfriend cheated on you ______
8. Lots of deadlines to meet ______
9. Property stolen ______
10. You have a hard upcoming week ______
11. Went into a test unprepared ______
12. Lost something (especially wallet) ______
13. Death of a pet ______
14. Did worse than expected on test ______
15. Had an interview ______
16. Had projects, research papers due ______
17. Did badly on a test ______
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>18.</td>
<td>Parents getting divorced</td>
</tr>
<tr>
<td>19.</td>
<td>Dependent on other people</td>
</tr>
<tr>
<td>20.</td>
<td>Having roommate conflicts</td>
</tr>
<tr>
<td>21.</td>
<td>Car/bike broke down, flat tire</td>
</tr>
<tr>
<td>22.</td>
<td>Got a traffic ticket</td>
</tr>
<tr>
<td>23.</td>
<td>Thoughts about future</td>
</tr>
<tr>
<td>24.</td>
<td>Lack of money</td>
</tr>
<tr>
<td>25.</td>
<td>Dealt with incompetence</td>
</tr>
<tr>
<td>26.</td>
<td>Thought about unfinished work</td>
</tr>
<tr>
<td>27.</td>
<td>No sleep</td>
</tr>
<tr>
<td>28.</td>
<td>Sick, Injury</td>
</tr>
<tr>
<td>29.</td>
<td>Had a class presentation</td>
</tr>
<tr>
<td>30.</td>
<td>Applying for a job</td>
</tr>
<tr>
<td>31.</td>
<td>Fought with boy/girlfriend</td>
</tr>
<tr>
<td>32.</td>
<td>Working while in school</td>
</tr>
<tr>
<td>33.</td>
<td>Arguments, conflicts of values with friends</td>
</tr>
<tr>
<td>34.</td>
<td>Bothered by having no social support of family</td>
</tr>
<tr>
<td>35.</td>
<td>Performed poorly at a task</td>
</tr>
<tr>
<td>36.</td>
<td>Didn’t finish everything you needed to do</td>
</tr>
<tr>
<td>37.</td>
<td>Heard bad news</td>
</tr>
<tr>
<td>38.</td>
<td>Had confrontation with an authority figure</td>
</tr>
<tr>
<td>39.</td>
<td>Maintaining a long-distance boy/girlfriend</td>
</tr>
<tr>
<td>40.</td>
<td>Crammed for a test</td>
</tr>
</tbody>
</table>
41. Felt unorganized
42. Trying to decide on major
43. Felt isolated
44. Parents controlling with money
45. Couldn't find a parking space
46. Noise disturbed you while trying to study
47. Someone borrowed something w/o permission
48. Had to ask for money
49. Ran out of toner while printing
50. Erratic schedule
51. Couldn't understand your professor
52. Trying to get into your major or college
53. Registration for classes
54. Stayed up late writing a paper
55. Someone you expected to call did not
56. Someone broke a promise
57. Couldn't concentrate
58. Someone did a "pet peeve" of yours
59. Living with boy/girlfriend
60. Felt need for transportation
61. Bad hair day
62. Job requirements changed
63. No time to eat
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>64.</td>
<td>Felt some peer pressure</td>
</tr>
<tr>
<td>65.</td>
<td>You had a hangover</td>
</tr>
<tr>
<td>66.</td>
<td>Problems with your computer</td>
</tr>
<tr>
<td>67.</td>
<td>Problem getting home from bar when drunk</td>
</tr>
<tr>
<td>68.</td>
<td>Used a fake ID</td>
</tr>
<tr>
<td>69.</td>
<td>No sex in a while</td>
</tr>
<tr>
<td>70.</td>
<td>Someone cut ahead of you in line</td>
</tr>
<tr>
<td>71.</td>
<td>Checkbook didn't balance</td>
</tr>
<tr>
<td>72.</td>
<td>Visit from a relative and entertaining them</td>
</tr>
<tr>
<td>73.</td>
<td>Decision to have sex on your mind</td>
</tr>
<tr>
<td>74.</td>
<td>Spoke with a professor</td>
</tr>
<tr>
<td>75.</td>
<td>Change of environment</td>
</tr>
<tr>
<td>76.</td>
<td>Exposed to upsetting TV show, book, etc.</td>
</tr>
<tr>
<td>77.</td>
<td>Got to class late</td>
</tr>
<tr>
<td>78.</td>
<td>Holiday</td>
</tr>
<tr>
<td>79.</td>
<td>Sat through a boring class</td>
</tr>
<tr>
<td>80.</td>
<td>Favorite sporting team lost</td>
</tr>
</tbody>
</table>
Satisfaction With Life Scale

Below are five statements that you may agree or disagree with. Using the 1 - 7 scale below, indicate your agreement with each item by placing the appropriate number on the line preceding that item. Please be open and honest in your responding.

7 = Strongly agree  
6 = Agree  
5 = Slightly agree  
4 = Neither agree nor disagree  
3 = Slightly disagree  
2 = Disagree  
1 = Strongly disagree

___ In most ways my life is close to my ideal.
___ The conditions of my life are excellent.
___ I am satisfied with my life.
___ So far I have gotten the important things I want in life.
___ If I could live my life over, I would change almost nothing.
**The PILL**

Several common symptoms or bodily sensations are listed below. Most people have experienced most of them at one time or another. We are currently interested in finding out how prevalent each symptom is among various groups of people. On the page below, write how frequently you experience each symptom. For all items, use the following scale:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Have never or almost never experienced the symptom</td>
<td>Less than 3 or 4 times per year</td>
<td>Every month or so</td>
<td>Every week or so</td>
<td>More than once every week</td>
</tr>
</tbody>
</table>

___1. Eyes water
___2. Itchy eyes or skin
___3. Ringing in ears
___4. Temporary deafness or hard of hearing
___5. Lump in throat
___6. Choking sensations
___7. Sneezing spells
___8. Running nose
___9. Congested nose
___10. Bleeding nose
___11. Asthma or wheezing
___12. Coughing
___13. Out of breath
___14. Swollen ankles
___15. Chest pains
___16. Racing heart
___17. Cold hands or feet even in hot weather
___18. Leg cramps
___19. Insomnia or difficulty sleeping
___20. Toothaches
___21. Upset stomach
___22. Indigestion
___23. Heartburn or gas
___24. Abdominal pain
___25. Diarrhea
___26. Constipation
___27. Hemorrhoids
___28. Swollen joints
___29. Stiff or sore muscles
___30. Back pains
___31. Sensitive or tender skin
___32. Face flushes
___33. Tightness in chest
___34. Skin breaks out in rash
___35. Acne or pimplles on face
___36. Acne/pimplles other than face
___37. Boils
___38. Sweat even in cold weather
___39. Reactions to insect bites
___40. Headaches
___41. Feeling pressure in head
___42. Hot flashes
___43. Chills
___44. Dizziness
___45. Feel faint
___46. Numbness - any part of body
___47. Twitching of eyelid
___48. Twitching other than eyelid
___49. Hands tremble or shake
___50. Stiff joints
___51. Sore muscles
___52. Sore throat
___53. Sunburn
___54. Nausea

---

Since the beginning of the semester, how many:

_____ Visits have you made to the student health center or private physician for illness  
_____ Days have you been sick  
_____ Days your activity has been restricted due to illness
**IPAQ**

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the last 7 days. Please answer each question even if you do not consider yourself to be an active person.

Think about all the vigorous activities that you did in the last 7 days. Vigorous physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

1. During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, aerobics, or fast bicycling?
   
   ____ days per week
   
   □ No vigorous physical activities ➔ *Skip to question 3*

2. How much time did you usually spend doing vigorous physical activities on one of those days?
   
   ____ hours per day
   
   ____ minutes per day
   
   □ Don’t know/Not sure

Think about all the moderate activities that you did in the last 7 days. Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.
   
   ____ days per week
   
   □ No moderate physical activities ➔ *Skip to question 5*
4. How much time did you usually spend doing moderate physical activities on one of those days?

   _____ hours per day
   _____ minutes per day

   [ ] Don’t know/Not sure

Think about the time you spent walking in the last 7 days. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure.

5. During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

   _____ days per week

   [ ] No walking  ➔ Skip to question 7

6. How much time did you usually spend walking on one of those days?

   _____ hours per day
   _____ minutes per day

   [ ] Don’t know/Not sure

The last question is about the time you spent sitting on weekdays during the last 7 days. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the last 7 days, how much time did you spend sitting on a week day?

   _____ hours per day
   _____ minutes per day
☐ Don’t know/Not sure
Curriculum Vitae

Kenia M. Castellanos

Education

2011  Rutgers University, New Brunswick, NJ
       Ph.D Cognitive Psychology

2005  Rutgers University, New Brunswick, NJ
       M.S. Cognitive Psychology

2002  SUNY Binghamton, Binghamton, NY
       B.A. Psychology/English

Positions held

2006-2010  Summer Lecturer
2009      Head Teaching Assistant
2006      Laboratory Instructor
2004-2006  Recitation Instructor
2007-2010  Teaching Assistant

Publications
