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Odor in the global environmental context: The effect of odor context reinstatement on memory

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Previous research has demonstrated that memory is dependent on the environmental context; memory is better when the same environmental context cues present at study are reinstated at test as compared to when they are not. This finding is called *context reinstatement effects* (Godden & Baddeley, 1975; Smith, Glenberg, and Bjork, 1978; Smith & Vela, 2001). What is unclear is whether study items are associated with the global context or with unique features within the study environment. We tested whether reinstating a singular feature of a global environment, the odor present during study, was sufficient to produce context reinstatement effects. These results indicated that, in a global environmental context, the global context is not being used as a cue for all the studied items rather than unique aspects of the environment serving as unique cues.

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CHAPTER I

INTRODUCTION

Returning to the environment in which an experience occurred can help us remember the details of that experience, a finding called context reinstatement effects (for a review see Smith, 1994, 2013). Context reinstatement effects have been investigated extensively (Godden & Baddeley, 1975; Smith et al., 1978; Smith, 1979; Fernandez and Glenberg, 1985; Smith & Vela; 1992; Smith & Vela, 2001; Smith, 2013). The typical paradigm used to demonstrate context reinstatement effects have participants study information in one context and then test their memory for the information in either the same (reinstated) or different context. Memory is typically better when people are tested in the reinstated context than in a different context, resulting in context reinstatement effects. A classic example of context reinstatement effects was shown by Godden and Baddeley (1975). Participants learned lists of words on land or under water wearing scuba gear. Then half of the participants completed a free recall test in a different context and half in a reinstated context. For instance, participants who studied on land were tested either under water or on land and memory was better when context was reinstated than when it was different. Following this typical paradigm, context reinstatement effects have been obtained in a variety of contexts, including different laboratory rooms (Smith, 1979, 1982; T. Isarida & T.K. Isarida, 2004; T. Isarida, 2005), a lounge versus a flotation tank (Smith & Sinha, 1987), different classrooms (Abernethy, 1940; Smith & Rothkopf, 1984; Saufley et al., 1985), over the phone versus in a lab (Canas & Nelson, 1986), and wearing orange-lensed goggles or not (Dolinsky & Zabrucky, 1983). Environmental context effects have been shown to be a modest, but reliable effect. Smith and Vela (2001) conducted a meta-analysis that included 75 studies reporting 93 effect sizes for experiments examining environmental context effects. Inclusion in the meta-analysis required that the context be: a) incidental to the studied information, b) slow changing, and c) extrinsic to the studied items. Eighty-seven percent of the experiments reported context effects; the average effect size for all the studies was $d = .28$.

The concept of what comprises environmental context is a point of discussion in the literature (T. Isarida & T.K. Isarida, 2004; T. Isarida, 2005; Smith, 2013). Traditionally, environmental context has been defined as the incidental information about the environment in which studied information is being processed (e.g., classroom, under water, sounds, odors, and moods). Environmental context has also been called *global* context because environmental cues change slowly or do not change at all during the study event (Glenberg, 1979). Context reinstatement effects occur under these conditions because memory is associative in nature with a benefit to memory of providing associated or related cues that are linked to studied information (Calkins, 1894). Theoretically, cues from the global environment in which information is studied become associated with studied information, and when those cues are again present at test, the prior association between the environmental cue and the studied item facilitates retrieval compared to when those cues are not available at test.

The benefit for memory of being provided with the same cues at test as were present at study is also demonstrated by the *encoding specificity principle* (Tulving & Thomson, 1973). Participants studied the target “flower” either without a cue or with the cue “fruit.” At test, they were given either no cue, the studied cue, or the cue “bloom,” which should be an optimal cue for “flower.” Memory was best when the studied cue was provided as compared to when no cue or the “optimal” cue was provided. When the studied cue is provided at test, the study context is reinstated, resulting in better memory than when the study context is changed by providing a different cue. In the case of global environmental contexts, the environment in which the target is studied becomes the study cue that is associated with the target and later serves as the best cue for remembering that studied target as compared to cues from a different environment.

The Search of Associative Memory (SAM) model (Raaijmakers & Shiffrin, 1981) provides a computational model of how context reinstatements effects occur in memory. During encoding, studied items are associated to each other, to themselves, and to the study context. At retrieval, the contextual cues serve as the first probes of memory. The success of retrieval depends upon the strength of the association between the cue and the target. Therefore, when the context cue provided was not part of the study event, the association between it and the to-be-remembered target is weak, making it a poor cue. The stronger association between the study context and the to-be-remembered target increases the probability of retrieval of that target, resulting in better memory when the context is reinstated than when it is not. Memory can still be successful even when the environmental cues are weak, because other cues can produce the to-be-remembered target, including retrieval of other words on the list (Postman, 1971) or by providing categorical cues (Tulving & Pearlstone, 1966).

Context can be operationalized as the complex, global environment in which information is studied. As discussed, most studies demonstrating context reinstatement effects have defined context in this way, with context ranging from flotation tanks to classrooms. What is not well understood is whether the entire environment serves as a global cue for study items or individual features of the environment serve as unique cues for each item. An examination of research using *local context*, could provide some insight. Local context, in contrast to global context, is defined as context cues that change with each study item as it is presented (Glenberg, 1979). Studies examining local context have tested whether context reinstatement effects are obtained when these local context cues are reinstated at test. Local context has been manipulated by using unique computer backgrounds (Wright & Shea, 1991; Murnane & Phelps, 1994; T. Isarida & T.K. Isarida, 2007; Sakai et al., 2010; Finch et al., 2016), unique spatial locations on a computer screen (Murnane & Phelps, 1993), and unique videos (Smith & Manzano, 2010; Smith et al., 2013; Smith & Handy, 2014) as contexts for each individual study items. For instance, T. Isarida and T.K. Isarida (2007) presented a list of words one by one on one of two alternating background colors on a computer screen. Because the background color was quickly alternating from word to word, this manipulation fit the definition of local context because the critical feature of local context is that it is quickly changing across study items (Glenberg, 1979; Isarida & Isarida, 2007), in contrast to global context which changes slowly (Glenberg, 1979). At test, only one of the colors was presented to create a context reinstatement condition for some of the items and a context change condition for others; recall was better when the color context was reinstated than when it was changed. Local context reinstatement effects require that the context changes across study items but are strongest when the context is not repeated across sets of items. Smith and Manzano (2010), demonstrated that a ratio of 1:1, context:study item, is optimal for obtaining context reinstatement effects. Isarida and Isarida (2007) showed that presenting items serially with one color background, rather than changing backgrounds for each item, failed to produce context reinstatement effects. These results demonstrate that it is not the proximity of the context to the study item that is important; rather it is the unique, changing context for each study item that produces local context reinstatement effects (Glenberg, 1979; T. Isarida & T.K. Isarida, 2007; Smith & Manzano, 2010).

Still in question is whether the research on local context reinstatement effects informs the original question of whether global environmental context reinstatement effects are due to a shared context across study items or due to unique aspects of the environment that are associated with the studied item. The local context reinstatement effects suggest that in a rich global environmental context with many changing contextual cues, individual study items each could be associated with a unique cue from the environment. Alternatively, it could be the case that, even in these rich environments, the entire context is used as a cue for all the study items to produce context reinstatement effects under global environments.

The purpose of Experiment I was to examine whether reinstating a single cue from a global environment would be sufficient to obtain context reinstatement effects. By reinstating just one aspect of a global environmental context, this procedure could tease apart whether context reinstatement effects are obtained when just one aspect of a global environment is reinstated. If studied words benefit from the reinstatement of the global context when they share the same environmental cue, this finding would show that the entire global context can serve as a cue for multiple study items. Participants studied and were tested on a list of categorical words in the same office environment. An odor was dispensed in the office during study and either reinstated or changed during test. A no-odor condition was included to test for context reinstatement effects associated with the office context alone serving as the global environment.

Odor was chosen as the single environmental cue because, anecdotally, odor is viewed as a powerful cue for memory. People have reported experiences of being spontaneously reminded of an autobiographical memory by the presence of an odor (Laird, 1935). This effect has become known as the Proust phenomenon (Chu & Downes, 2000), named after the literary author Marcel Proust. Proust described a childhood experience after his memory was cued by smelling a teasoaked pastry (as cited in Chu & Downes, 2000, p. 111). Since Proust's observation, research has supported his view that odor is an effective retrieval cue, particularly for autobiographical memories (Herz & Cupchick, 1992; Herz & Engen, 1996). For example, Herz and Cupchick (1992) asked participants to smell a variety of pleasant and unpleasant odors, ranging in familiarity and relatively distinctiveness among them. Participants smelled each odor and rated it for pleasantness, familiarity, intensity, arousal, and degree of interest. Lastly, they were asked to name the odor and whether the odor brought any memories to mind. If the odor evoked memories, then people rated the memory for emotionality, clarity, specificity, rarity, and age. Memories cued by odors were rated as more emotional, very clear, specific, rarely thought of, and relatively old. Also, autobiographical memories cued by odors consistently were less thought of and talked about compared to memories cued by words or images (Rubin et al., 1984), highlighting the powerful nature of an odor cue for these distant memories. Another reason that odor might be a particularly good cue for memory is because of the biological bases for processing memory in the brain. In the brain, the primary olfactory cortex is directly connected to the amygdala-hippocampal complex. This direct connection is important for memory because the hippocampal complex is important for both encoding and retrieval in memory (Eichenbaum, 2001). This connection is also stronger for odor than for other sensory stimuli, which are first processed by the thalamus (Tham et al., 2009).

Odor, as a global environmental context cue, has shown to function as an effective retrieval cue in the context reinstatement paradigm. Schab (1990) introduced odor into a room in which participants studied a list of words. Twenty-four hours later, participants returned to the same classroom where either the same odor, a different odor, or no odor was present. Context reinstatement effects were obtained; more words were remembered when the odor was reinstated during test than when the odor was changed. Additionally, Cann and Ross (1989) had participants study people's photographs when a pleasant or unpleasant odor was present in a room. After a 48-hour interval, when the odor was reinstated, more photographs were accurately recognized than when the odor was changed. Regardless of the odor's nature, memory was always better when the odor was reinstated than when it was changed.

The reason that odor could function as an effective retrieval cue in a global environmental context could be because it is distinctive to the rest of the environment (Herz, 1997). Some researchers suggest that for the global environmental context to be incidentally associated with the studied information, the cues will need to be unique for them to be reliable and effective at retrieval when the global environmental context is reinstated (Bjork & Richardson-Klavehn, 1989). Therefore, the inappropriateness of the odor in the global environmental context could allow an odor cue to be unique and serve as an effective retrieval cue. The odor cue can be familiar, but if it is perceived to be inappropriate in the global environmental context, then the inappropriateness makes the odor distinctive compared to the other environmental cues.

Overall, the studies finding context reinstatement effects using odor provide evidence that odor can function as an effective retrieval cue in a global environmental context. However, some researchers suggest that for the global environmental context to be incidentally associated with the studied information, the cues will need to be unique for them to be reliable and effective at retrieval when the global environmental context is reinstated (Bjork & Richardson-Klavehn, 1989). The requirement of uniqueness follows the majority of studies examining context reinstatement effects by primarily reinstating or changing a perceptually rich global environmental context (Smith et al., 1978; Smith, 1979). A single odor may not be an effective retrieval cue when other aspects of the environment are not also changing, especially when reinstating just one aspect of a global environmental context. In a rich global environmental context, each target could be associated to a unique aspect of the environment, but with odor being the only reinstated or changed cue, there could be interference from multiple targets associated with this single cue or this single cue could be overloaded (Watkins & Watkins, 1975). Overloading occurs when multiple target items are associated with one cue, weakening associations between the cue and each subsequent target. Therefore, for multiple reasons, changing just one aspect of a global environment could reduce the ability of that single cue to evoke memories for study items.

CHAPTER II

EXPERIMENT I

The purpose of Experiment I was to extend the research investigating whether context reinstatement effects are obtained when reinstating only one aspect of the global environmental context, in this case the odor present during study. Several methodological issues from prior studies will be addressed in this study, including the use of a shorter retention interval and isolating odor as a global environmental context cue. Based on the prior research of odor and context reinstatement effects, odor should be an effective retrieval cue when the odor present during study is reinstated at test. I hypothesized that context reinstatement effects would be obtained such that more words would be recalled when the study odor was reinstated at test than when it was changed or absent.

Materials and Method

Participants and Design

A total number of 350 Mississippi State University undergraduate students volunteered to participate for course credit via the Sona-Systems Psychology Research Pool. Participants were informed not to enroll in the study if they were sensitive to odors. The experimental design was a one-way design with 3 levels (Context Type: reinstated odor, changed odor, no odor). Context Type was manipulated between subjects and participants were randomly assigned to each of the three Context Type conditions.

Word Lists

Two lists of 40 words from 8 categories (5 words per category) were created for the study using a category norms database (e.g., types of fabric: suede, jean, velvet, fleece, linen; Van Overschelde et al., 2004). In prior experience, an unrelated list of words produced low free recall results; therefore, categorical lists were created to boost free recall. Prior research has shown that free recall is better for a list of categorizable words than a list of unrelated words (Tulving & Pearlstone, 1966). The full lists are available in Appendix A. The exemplars for each category were chosen based on the likelihood of producing that item given the category cue. The category members with the likelihood greater than or equal to .05 and less than .23 were selected to have any effects in recall be due to memory rather than guessing of highly likely category members. Which list was studied was counterbalanced.

Odors

Two different ArtNaturals 100% pure essential oils (lemon and peppermint) were used as the odors for the experiment. The odors were presented using an URPOWER 2nd version oil diffuser. The diffuser was started an hour before participants arrived. After each completed session, the experimenter added three drops of the selected odor, so that the odor was consistent across sessions. Participants were told that the diffuser was there in order to freshen the air because the building was old and musty.

Other Materials

A digital consent form was created and presented prior to the instructions for the experiment. The consent form is available in Appendix B. Also, a post-experimental questionnaire was created to be completed at the end of the experiment.

Four questions asked: “Did you notice anything about the experiment that you like to comment on?”, “What were the differences you noticed, if any?”, “Was the odor the same or different throughout the experiment?”, and “What was the odor in the room, if any?”

Procedure

Using one experimental room, two computers, and the software E Prime 2.0, two participants at a time completed a study phase, JOL phase[1], interval phase, and test phase for a one-hour session. After completing the consent form, participants provided consent and started the experiment by hitting the enter key on the computer. Participants were told to study each word so that they could recall the word for a later test. Each word was presented on the screen for eight seconds.

After completing the study phase, participants were instructed to wait for more instructions from the experimenter. During this wait time, for the changed odor context condition, the experimenter changed the diffuser to diffuse a different odor. The experimenter told the participants “Sorry, but the water is about to run out of this diffuser, and I need to add some more.” They then removed the diffuser to an adjacent office and returned with another diffuser that was prepared with a different odor. The experimenter plugged the new diffuser in, changing the odor being diffused. After, participants then were instructed to proceed with the study. The purpose of changing the diffuser prior to the interval phase was to allow the new odor to diffuse during the interval task long enough to eliminate the previous odor and diffuse the new

[1] After studying each word for eight seconds, the word disappeared and was replaced with a judgement of learning (JOL) prompt. The students were asked to make a prediction on how certain they were to remember the word on a 0 (WILL NOT remember) – 100 (WILL remember) scale. Additionally, they were reminded to use the full scale when making the prediction and had five seconds to make the prediction. The results from the JOLs will not be discussed in this document.

odor to the same level by the time of the recall phase; the timing was determined by testing prior to implementing this procedure in the experiment. Participants in the reinstated odor context and no odor context conditions waited as well, until the experimenter instructed them to proceed with the experiment. The interval phase consisted of solving problems from the Ravens problem solving task, lasted for 10 minutes, and was followed by the test phase.

During the test phase participants were instructed to freely recall as many words as they could by typing their responses on the keyboard. Participants were given an unlimited time to recall the words. After completing the test phase, students then completed the post-experiment questions.

Results

Although 350 participants were tested, not all met the inclusion criteria to be in the analysis. Forty-three participants were excluded because of not following directions, power outages during the experiment on multiple occasions, participant looking at the other participant's screen, participant being under the influence, and missing data files. In addition, an inclusion criterion was set requiring at least 20 percent recall (at least 8 words out of 40); another 56 students were excluded due to not meeting this criterion. The total number of participants included in the analysis was 251. Descriptive information is shown in Table 1. For analysis of mean differences in memory performance, R (R Core Team, 2019) was used to calculate the *t*-tests and the ANOVA.

An independent-samples *t*-test was conducted to compare mean proportion of recall for list one and list two to collapse across list type. There was not a significant difference in mean proportion of free recall for list one (M = .44, SE = .04) and list two (M = .40, SE = .03), $t(249)$ = 1.94, p = .05. Therefore, recall for list type was collapsed across for subsequent analyses.

Table 1 *Descriptive Statistics for each Condition and Odor Counterbalance*

Context Condition	Odor at Study	Odor at Test	*M*	*SD*	*n*
Reinstated Odor	Lemon	Lemon	.40	.17	45
	Peppermint	Peppermint	.41	.15	52
Changed Odor	Lemon	Peppermint	.42	.16	48
	Peppermint	Lemon	.44	.17	46
No Odor	None	None	.42	.16	60

Next, an independent-samples *t*-test was conducted to compare mean proportion of recall for lemon and peppermint for the changed odor context. This condition was treated as the baseline condition. There was no significant difference in proportion of free recall for lemon (*M* = .42, *SE* = .06) and peppermint odors (*M* = .44, *SE* = .06); $t(92) = 0.79$, $p = .43$. Therefore, recall was collapsed across odor type for all other analyses.

A one-way ANOVA was conducted across the reinstated odor context, changed odor context, and no odor context conditions to compare the effects of odor context on memory. There was no effect of odor context on memory, $F(2,248) = 0.59$, $p = .56$; on average participants in the reinstated odor context (*M* = .40, *SE* = .04), changed odor text (*M* = .43, *SE* = .04), and no odor context (*M* = .42, *SE* = .05), had a similar proportion of recall.

Discussion

Experiment I found no evidence for context reinstatement effects. Participants recalled the same proportion of words at test, regardless of whether the odor context was reinstated or changed. This result was not expected and is not in line with previous research demonstrating a benefit for memory when study context is reinstated at test. Although context reinstatement effects can be small, it is robust (Smith & Vela, 2001). The limited number of studies that have examined odor as a context, most did obtain context effects (Cann & Ross, 1989; Schab, 1990; D. G. Smith & Standing de Man, 1992; Pointer & Bond, 1998; Parker & Gellatly, 1997; Parker, et al., 2001; but see Herz, 1997; Ball et al., 2010), but my findings failed to replicate context reinstatement effects. However, there are inconsistencies between my study and prior studies that could explain why context reinstatement effects were not obtained in Experiment I.

One aspect of my study that differed from prior odor context studies was the materials used. Prior studies used pictures (Cann & Ross, 1989), prose passages (Pointer & Bond, 1998), or common English adjectives (Schab, 1990). The present study used exemplars from 8 distinct categories. These categorical lists were used to counter prior experience with low rates of free recall because prior research has shown that free recall is better for a list of categorizable words than a list of unrelated words (Tulving & Pearlstone, 1966). However, this type of list could have contributed to the lack of context reinstatement effects. According to Smith and Vela (2001), context reinstatement effects can be eliminated if the environmental context is suppressed at study when other factors, such as those that benefit from associative processing, prove to be more effective. This view is called the *overshadowing hypothesis* (Smith & Vela, 2001). Previous research has identified inter-item associations as potential cues that mask contextual cues when investigating context effects (Smith & Vela, 2001). Therefore, the use of categorizable words could have encouraged associative processing as participants used semantic organization to study the words, suppressing associations to the environmental context. Using Smith and Vela's terminology, the context of associative processing overshadowed the environmental context to the degree that no environmental context would have been associated with and encoded with the studied words.

Related to overshadowing is the *outshining hypothesis* (Smith, 1988, 1994; Smith & Vela, 2001). As people did associative processing during encoding, they also generated associative cues. According to this hypothesis, associative cues can outshine environmental cues at retrieval. Providing a category name as a cue at retrieval could have resulted in outshining any environmental contextual cues. Further, retrieving one category member could have served as a more powerful cue for other words in the same category than any contextual cue.

Another aspect that could have led to no context reinstatement effects was the odors selected for this study. Although lemon and peppermint perceptually are distinctive from each other, they may not have been distinctive from the environment in which they were being diffused. Herz (1997) defined the distinctiveness of odor as being novel and inappropriate to an environmental context. She found that obtaining context reinstatement effects was dependent on the distinctiveness of the odor used from the environment in which it was being smelled. For instance, in a laboratory setting, she obtained context reinstatement effects using osmanthus and peppermint, but not when using fresh pine. She concluded that the fresh pine smell failed because it was perceived as part of the global environment (i.e., cleaning products used in institutions are often pine-scented). Based on post-experimental reports, some participants in my study perceived both lemon and peppermint as scents related to cleanness or cleaning products. Therefore, these odors may not have been distinctive from the global environment in which they were diffused and therefore would not have served as contextual cues for study information. Without the perception of the odor as distinctive from the office environment, the global environment was the same regardless of which odor was diffused.

Finally, ironically, it could be said that by allowing participants to remain in the same room while moving the odor context, it could be said that context was never reinstated. In the context reinstatement condition, participants remained in the same room for both study and test; they never left the room. Because they never left the room and came back, the context was continuous rather than reinstated. It was the same odor at study and test, but the concept of reinstatement suggests some kind of interval between study and test that is neutral so that the context can be reinstated. This reinstatement did not actually happen; in effect the context remained "stated" throughout the experiment.

Another reason the context may not have been reinstated using our procedure is due to adaptation. Adaptation occurs when sensitivity to an odor decreases over time. Odor is believed to be adapted to within a 20-minute time interval (Herz, 2016; Stuck et al., 2013; Dalton, 2000). Because participants never left the room and the same odor was continuously diffused during the session, participants could have adapted to the odor long before the test phase. Therefore, the odor context may not have been reinstated because the odor itself may have no longer been perceived by the time of the test.

CHAPTER III

EXPERIMENT II

The purpose for Experiment II was to further investigate whether a singular cue from a global environment, such as odor, can serve as an effective cue for context reinstatement while addressing limitations from Experiment I. The first problem to solve was to eliminate the potential for overshadowing at study and outshining at test that occurred because of the use of categorical words and cues. Overshadowing occurs when a stronger cue during study suppresses a weaker cue. Outshining occurs when a cue other than context is more beneficial to retrieval on the test. Previous research has identified inter-item associations as potential cues that mask contextual cues when investigating context effects (Smith & Vela, 2001) and using categorizable words could have emphasized associations among study items and overshadowed the potential for associations between the global environmental context cue of odor and the study items. In addition, my use of intentional study instructions could have increased the likelihood of using these inter-item semantic organization study strategies rather than associations between the context cue and the studied items. Then providing a categorical cue at tests could have outshone potential environmental cues at test. These problems were addressed be creating new word lists consisting of unrelated words for which creating inter-item associations within the list would be difficult. In addition, incidental study instructions were used; participants studied by rating each word for pleasantness without forecasting that there would be a test. This procedure would also serve to potentially boost free recall, overall. Finally, no cues were provided to aid with recall on the final test. By not providing any kind of cue (i.e., a category name) at test, nothing will be provided to outshine the potential association between an environmental contextual cue and the study information.

The second methodological issue to address was that of the distinctiveness of the odors selected. Whereas clean and fresh scents like peppermint and lemon could have been perceived as inherent to the environmental context, three distinctive odors, not likely to be encountered in an office building, were selected for Experiment II. Clove bud, eucalyptus, and dill weed were chosen because they are all three distinctive from an office environment, but also, they each belong to a unique and separate group of scents as measured by a factor analysis (see Materials). Finally, to address the failure to actually reinstate context and to protect against adaptation, I replicated a paradigm designed by Isarida et al. (2014). This paradigm adds an intermediate environment after the study context and before the test context that serves as a "recovery" room (Isarida et al., 2014, p.423). After studying a list of words in Booth A, participants were moved to Booth B for an interval task. Then after the interval task participants were moved to Booth C to recall the list of words studied in Booth A. The odor that was presented in Booth A was either reinstated or changed when participants were moved to Booth C. During the interval task, a different odor that was not used for the reinstated context condition or changed context condition was presented. This second odor was used to disrupt adaptation to the odor presented in Booth A, so that when the odor was reinstated in Booth C, it would be perceived. Using this recovery method, Isarida et al. (2014) obtained odor context reinstatement effects.

Although Isarida et al. (2014) solved the problem with adaptation by using the recovery method, there are potential problems with their implementation of the procedure. Although they called their three contexts "booths," upon closer examination, these were really three different areas in one large open room. They were not closed off and, although participants faced a wall or corner, the other areas of the room were visible to them. Because of this, the actual context could have been the larger context of the room with some unique features changing depending on the individual booth, including the odor. In addition, the potential for interference from the three odors was high using this procedure. There was nothing to prevent the odor from wafting to another area of the room. Also, not only did the three booths share the larger global context of the room itself, the three booths also shared some contextual details with each other, although there also were unique cues present within each booth. Finally, because all three booths were in the same large room, the potential for mentally reinstating the study context was high. Smith (1979) showed that context reinstatement effects can be obtained when participants mentally reinstate the environmental cues from study, even when they are tested in a different environment. Overall, Isarida et al., (2014) obtained context reinstatement effects when reinstating the odor context; however, our goal with Experiment II is to tighten up the recovery procedure to address these potential issues so that any context reinstatement effects could be associated with the odor reinstatement or change alone.

To determine whether targets are associated with a single aspect of a global environment—in this case odor—in Experiment I we tried to keep the global environment static between study and test and only reinstate or change the odor. However, maintaining the global environment produced several unintended effects, which the current procedure resolves. However, the new procedure does not allow for manipulating only odor while maintaining a static rich global environment. Therefore, the new strategy was to manipulate odor within a sparse global environment in which the only available contextual cue was the odor. Now with the only contextual cue being the singular cue of odor, the goal is to determine whether this cue alone is sufficient to elicit context reinstatement effects to determine whether context reinstatement effects can be obtained at all when there is only one shared contextual cue available for all study items. In order to achieve a sparse global environment and implement the recovery procedure (Isarida et al., 2014), we used three separate rooms in order to prevent interference across odors and to allow for recovery from adaptation to the study odor before it was reinstated at test. To avoid interference with the odor cue from other contextual cues in each room that were not being reinstated and to isolate odor as the environmental context, each room was wrapped in a different colored sheet to create cubicles. Only a testing station with a computer and chair was visible in each room and this was consistent across the three rooms. Even the testing table was covered with a pillowcase that matched the sheets creating the cubicle. As shown in Figure 1, the color of the chairs did not match the cubicle color but was different for each cubicle.

Experiment II resolved each of the three problems identified in the methodology used in Experiment I as well as the potential issues with the Isarida et al (2014) recovery method with the goal of determining whether reinstating a single cue from a sparse global environment would be sufficient to obtain context reinstatement effects. Incidental encoding instructions were provided to learn a list of unrelated words as distinctive odors were diffused in three separate rooms made sparse by wrapping them in sheets. The recovery method was used to eliminate any effects of adaptation. Participants were tested in a new room in which the odor diffused at study was diffused (reinstatement condition) or a new odor was diffused (change condition).

Figure 1 *Cubicles Created to Form a Sparse Global Environment*

The figure shows how three rooms were transformed to create three cubicles in a sparse global environment. The sheets and pillowcases used were gray, teal, and red.

Whereas the goal of Experiment I was to determine whether reinstating a single cue from a rich global environment would be sufficient to obtain context reinstatement effects, Experiment II addresses that same goal by changing a single cue in a sparse global environment. If context reinstatement effects are obtained in this sparse environment where only the odor cue is reinstated, the results would suggest that targets are associated with the entire global environment during study rather than associating each target with a unique cue from within a rich global environment.

Pilot Experiment

Before introducing odor as the singular environmental cue, the role of the sheets alone at producing context reinstatement effects was examined. Although participants were tested in a new cubicle regardless of the context reinstatement condition in Experiment II, there was the potential for an effect of mental reinstatement of the sheet color from the studied phase. Therefore, the effect of explicitly reinstating the context of the sheet from the study phase during test was tested.

Materials and Method

Design and Participants

The design was a simple two-group design comparing free recall between a group for which the sheet context from study was reinstated and a group for which it was changed. A total of 96 Mississippi State University undergraduate students volunteered for course credit via the Sona-Systems Psychology Research Pool.

Word Lists

Two lists of 24 unrelated words were created for the study using the University of South Florida (USF) Free Association Norms database (Nelson et al., 1998, 2004). Using ListChecker Pro 2.0 (Eakin, 2010), the list of words was checked to be sure there were no intralist associations. Also, as shown in Table 2, other word characteristics that impact memory, such as concreteness, frequency, set size, was equated across the two lists.

Procedure

Interval phase

Participants sat at one of the two testing stations in Cubicle 2. The interval task consisted of completing the Operation Span Task (OSPAN) for 10 minutes. After the 10-minute interval, participants were moved back to Cubicle 1 (reinstated condition) or to Cubicle 3 (changed condition).

Test phase

For the reinstated sheet context condition, participants went back to Cubicle 1 where the study phase occurred. For the changed sheet context condition, participants went to Cubicle 3 in which the sheet color was different from both Cubicle 1 and 2. Participants were informed

Table 2 *Word Characteristics for Two Lists*

Characteristics	List One		List Two	
	Mean	*SD*	*Mean*	*SD*
Cue Frequency (K&F	106.17	36.03	118.96	37.36
Cue Concreteness (Scale 1-7)	5.00	0.95	4.80	1.21
Cue Set Size	12.46	2.80	12.71	3.82
Number of Cue Competitors	9.54	2.77	8.83	3.53
Cue Competitor Strength	0.49	0.26	0.52	0.24
Mean Cue Connectivity	1.75	0.54	1.87	0.69
Cue Connectivity Strength	2.92	0.97	2.99	1.17
Cue Resonance Strength	1.86	0.88	2.07	0.96

Note: This table shows the mean and standard deviation for each word characteristic that was used in list one and list two. The lists were counterbalanced between participants.

of the surprise recall test, which was completed on the computer. Participants typed all the words they could remember from the study phase on the computer keyboard. The free recall phase was not timed. After participants indicated they recalled all the words that they could remember, the experimenter typed a shortcut on the keyboard that took participants to the post-experimental questionnaire. After completing the questionnaire, participants completed a sheet discrimination task.

Sheet Discrimination Task

Participants completed the sheet discrimination task one at a time with the experimenter. (The experimenter instructed the second participant to stand in the hallway, away from the experimental rooms.) The experimenter asked the participant to follow the experimenter into the Cubicle 1 and asked participants to look around the cubicle. Then the experimenter led the participant to their Cubicle 2. The experimenter asked participants whether Cubicle 2 looked the same or different than Cubicle 1. Participants in the reinstated condition were done with the sheet discrimination task after making the discrimination between Cubicle 1 and Cubicle 2. The experimenter thanked the participant and was shown to the exit. The second participant in the reinstated condition then completed sheet discrimination task.

Participants in the changed condition completed two more cubicle discriminations than the participants in the reinstated condition. After making the discrimination between Cubicle 1 and Cubicle 2, experimenter led the participant back to Cubicle 1. After instructing the participant to look around Cubicle 1 again, the experimenter escorted the participant to Cubicle 3. The experimenter asked the participant whether Cubicle 3 looked the same or different than Cubicle 1. After recording their answer, the experimenter led the participant back to Cubicle 2 and told the participant to look around the cubicle again. Then participant was led to Cubicle 3 and asked whether this cubicle looked the same or different to Cubicle 2. After completing the third cubicle discrimination, the experimenter thanked the participant and was shown to the exit. The second participant then completed the sheet discrimination task.

Results

Analysis of the results was done using R (R Core Team, 2019). Although 96 participants were tested, not all met the inclusion criteria. To be included in the final analysis, participants had to discriminate between Cubicle 1and Cubicle 3 correctly as “different.”. After applying the inclusion criteria the final analysis included 78 participants (*n* changed context = 42; *n* reinstated context = 36). First, an independent-samples *t*-test was conducted to ensure there was not a difference in memory performance based on the two lists. There was no significant difference in mean proportion of recall for list one (*M* = .26, *SE* = .05) and list two (*M* = .30, *SE* = .06), *t*(76) = 1.33, *p* = .19 Therefore, recall was collapsed across list type for all other analyses. Next, an independent-samples *t*-test was conducted to compare mean proportion of recall for reinstated sheet context and changed sheet context. There was not a significant difference in mean proportion of recall for reinstated sheet context (*M* = .29, *SE* = .05) and changed sheet context (*M* = .27, *SE* = .06), *t*(76) = 0.72, *p* = .48.

Pilot Study Discussion

The pilot study results ensured that the sheets themselves did not create context reinstatement effects, even when the test was administered in the same cubicle as the participant studied. This comparison served as the strongest test of whether the sheets alone could produce context reinstatement effects and they did not. In addition, any context reinstatement effects obtained in Experiment II are not likely to be due to mental reinstatement of the study context because explicit reinstatement failed to produce those effects.

Experiment II

Materials and Method

Design and Participants

The design was a simple two-group design comparing free recall between a group for which odor context is reinstated and a group for which odor context is changed. The number of participants was determined by examining prior research reporting significant odor context reinstatement effects and by conducting a power analysis using G*Power. Using an independent samples experimental design, G*Power returned a sample size of 80 for a large effect of .82, alpha .05, and .95 error probability. A large effect was used based on prior odor context reinstatement studies (Cann & Ross, 1989; Schab, 1990; Herz, 1997; Isarida et al., 2014). A total number of 83 Mississippi State University undergraduate students volunteered for course credit via the Sona-Systems Psychology Research Pool. The SONA header asked participants who were sensitive to odors to self-select out of the study.

Word Lists

The same two lists of unrelated words from the pilot study were used in Experiment II and shown in Appendix A. The lists were counterbalanced across participants and each list served equally often in each experimental condition.

Odors

Three Edens Garden 100% pure essential oils (clove bud, eucalyptus, and dill weed) were used in the experiment. The three odors were chosen based on Castro et al. (2013), which examined the categorical dimensions of odors. Using a factor analysis technique and an odor profile database, ten categorical dimensions were identified. For example, one of the categorical dimensions formed was fruity and citrus odors (e.g., lemon and orange). Another dimension was chemical odors (e.g., kerosene and varnish). The three odors used in this experiment were selected because they inhabited three different dimensions and did not overlap in terms of distance with any other dimension in the factor analysis matrix. In addition, they were deemed to be likely to be perceived as distinctive from odors typical to an office environment.

Odors were presented using an URPOWER 2^{nd} version oil diffuser. Diffusers were started an hour before participants arrived with .50 mL of the odor added to each diffuser. After each completed session, the experimenter added .25 mL of the specific odor, so that the odor was consistent across sessions. Odor sessions were counterbalanced so that odors were consistent within a given day (see Procedure). The odor sanitizer Ozium was used to eliminate odors at the end of each day to provide a clean room at the start of the next day.

The odor type was counterbalanced to create six reinstated and six changed odor context counterbalance conditions. As Table 3 shows, every odor was used in all phases and in each odor context condition. Combined with the list counterbalance, 24 counterbalance conditions were created.

Rooms

The same three rooms with the sheets as in the Pilot Study were used for Experiment II. The rooms were used in a fixed order for each participant.

Other Materials

As shown in Appendix B the same digital consent form was used as the Pilot Experiment. A post-experimental questionnaire was developed to include questions about self-reported odor discrimination ability among rooms. The full list of questions is available in Appendix C.

Procedure

Study Phase

Participants were tested up to two at a time. During the study phase, the experimenter directed the participants to have a seat in Cubicle 1 at one of the two computer stations; diffusion of the odor had already begun. The experimenter instructed participants to press the enter key on the keyboard to begin the experiment. First, a consent form was presented. Continuing the study after reading the consent form was considered providing consent. After consent was obtained, the instructions for the experiment were presented. Participants were given incidental encoding

Table 3 *Counterbalancing Odors*

Condition	Study Phase	Interval Phase	Test Phase
	Cubicle One	Cubicle Two	Cubicle Three
Reinstated Odor Context	Clove Bud	Dill Weed	Clove Bud
	Clove Bud	Eucalyptus	Clove Bud
	Eucalyptus	Clove Bud	Eucalyptus
	Eucalyptus	Dill Weed	Eucalyptus
	Dill Weed	Eucalyptus	Dill Weed
	Dill Weed	Clove Bud	Dill Weed
Changed Odor Context	Clove Bud	Dill Weed	Eucalyptus
	Clove Bud	Eucalyptus	Dill Weed
	Eucalyptus	Clove Bud	Dill Weed
	Eucalyptus	Dill Weed	Clove Bud
	Dill Weed	Eucalyptus	Clove Bud
	Dill Weed	Clove Bud	Eucalyptus

Note: This table shows the six reinstated odor context conditions and the six changed odor context conditions that were created based on counterbalancing the three odors used in the experiment.

instructions that did not disclose the final memory test. The participants were asked to rate the pleasantness of each word under the guise of helping develop materials for a future study. Each word was presented on the screen for eight seconds. During the presentation time, participants rated the word on its pleasantness by typing in U for unpleasant, N for neutral, or P for pleasant. Their ratings were recorded, but the words remained on the screen for the entire eight seconds regardless of when they made their rating. After all participants were finished with the study phase, they were moved to Cubicle 2.

Interval Phase

Participants were seated at one of the two testing stations in Cubicle 2; the second odor was already being diffused. Cubicle 2 allowed for recovery from adaptation of the odor used in Cubicle 1 for those in the reinstated odor context group. In addition, by following the recovery method suggested by Isarida et al. (2014), reinstating the study context after this recovery phase will create a true reinstatement of context. The interval task consisted of completing the Operation Span Task (OSPAN) for 10 minutes. After the 10-minute interval, participants were moved to Cubicle 3.

Test Phase

For the reinstated odor context condition, the same odor from Cubicle 1 was already being diffused in Cubicle 3. For the changed odor context condition, a third odor, different from the Cubicle 1 and Cubicle 2 odor, was already being diffused in Cubicle 3. Participants were informed of the surprise recall test, which was completed on the computer; participants typed all the words they could remember from the study phase on the computer keyboard. The free recall phase was not timed. After participants indicated they recalled all the words that they could remember, the experimenter typed in the keyboard a shortcut that took participants to the post-experimental questionnaire. After completing the questionnaire, participants completed a smell discrimination task.

Smell Discrimination Task

Participants completed the smell discrimination task one at a time with the experimenter. (The experimenter instructed the second participant to stand in the hallway, away from the experimental rooms.) The participant was led to Cubicle 1 by the experimenter and asked to breathe through their nose. After, the participant was led to Cubicle 2, and instructed again to breathe through their nose. The experimenter asked the participant whether the smell of Cubicle 2 was the same or different than Cubicle 1. Then the participant was led back to Cubicle 1 and instructed to breathe through their nose. After, the participant and experimenter went to Cubicle 3 and the participant was instructed to breathe through their nose. The experimenter asked the participant whether the smell of Cubicle 3 was the same or different than Cubicle 1. After, the participant was led back to Cubicle 2, and instructed to breathe through their nose, then they went back to Cubicle 3, and was asked whether the smell was the same or different than Cubicle 2.

All answers by the participant were recorded by the experimenter. For all participants the correct answer is different for the odor discrimination task between Cubicle 1 and Cubicle 2, and between Cubicle 2 and Cubicle 3. For participants in the reinstated context condition the correct answer was “the same” for the discrimination task between Cubicle 1 and Cubicle 3. For participants in the changed context condition the correct answer was “different” for the discrimination task between Cubicle 1 and Cubicle 3. After completing the final smell discrimination task, the experimenter thanked the participant and showed them to the exit. The second participant then completed the smell discrimination task.

Results

Analysis of the results was done using R (R Core Team, 2019). Four people were initially excluded due to not following the directions for the final recall test, which resulted in them not finishing the experiment[2]. Therefore, 79 participants were tested, but 53 participants were included in the final analysis after applying the inclusion criteria of getting the smell discrimination task correct between Cubicle 1 and Cubicle 3. Descriptive information is shown in Table 4. An independent-samples *t*-test was conducted to compare mean proportion of recall for list type. There was no significant difference between mean proportion of recall for list one (M = .20, SE = .06) and list two (M = .20, SE = .05), $t(51) = 0.01$, p = .99, and recall was

[2] The 20% criterion that was used in Experiment one was not used in Experiment II.

Table 4 *Descriptive Statistics for each Condition and Odor*

Context Condition	Odor at Study	Odor at Interval	Odor at Test	*M*	*SD*	*n*
Reinstated Odor	Clove Bud	Dill Weed	Clove Bud	.27	.10	3
	Clove Bud	Eucalyptus	Clove Bud	.24	.11	4
	Eucalyptus	Clove Bud	Eucalyptus	.22	.05	3
	Eucalyptus	Dill Weed	Eucalyptus	.28	.06	3
	Dill Weed	Eucalyptus	Dill Weed	.19	.04	5
	Dill Weed	Clove Bud	Dill Weed	.12	.06	4
Changed Odor	Clove Bud	Dill Weed	Eucalyptus	.17	.09	5
	Clove Bud	Eucalyptus	Dill Weed	.16	.11	6
	Eucalyptus	Clove Bud	Dill Weed	.18	.11	4
	Eucalyptus	Dill Weed	Clove Bud	.16	.07	6
	Dill Weed	Eucalyptus	Clove Bud	.24	.07	5
	Dill Weed	Clove Bud	Eucalyptus	.25	.14	5

collapsed across list type for all other analyses.

The changed context condition was considered the baseline condition because all three odors were used during the study, interval, and test phase; therefore, a one-way ANOVA was conducted to ensure that there was no difference between mean proportion of recall based on our counterbalance of the odors. There was not a significant difference for mean proportion of recall; clove bud (M = .16, SE = .09), eucalyptus (M = .17, SE = .09), and dill weed (M = .25, SE = .10) resulted in similar means of free recall, $F(2, 28) = 2.77$, $p = .08$. Therefore, recall was collapsed across odor type for all other analyses.

An independent-samples *t*-test was conducted to compare the mean proportion of recall between the reinstated odor context and the changed odor context. There was not a significant difference for the mean proportion of recall for reinstated odor context ($M = .21$, $SE = .06$) and changed odor context ($M = .19$, $SE = .06$), $t(51) = 0.92$, $p = .36$. Therefore, context reinstatement effects were not found.

Experiment II Discussion

In Experiment II, context reinstatement effects were not found when collapsing across odor type for the reinstated context and changed context conditions. These results were not expected after addressing the problems from Experiment I and implementing the recovery method.

The result of not finding context reinstatement effects is likely due to lack of power. The power analysis stated that 80 participants were required to observe significant effects if there were any. However, after applying the inclusion criteria, many participants were dropped, which was not expected. Twenty-six people were not included in the final analysis because of getting the odor discrimination task wrong between cubicles. On average, this loss was greater from the context reinstatement condition than the context change condition, with a count of six participants for each odor. On average, two people were lost for the changed context condition for each odor. Subtle changes in the amount of odor dispensing between the study and test cubicles could have led to people in the context reinstatement condition identifying the odors as different when they were, in fact, the same. Regardless, this differential loss of participants from the reinstatement condition created a lack of power to observe context reinstatement effects.

Perhaps instead of counterbalancing the odors, as in Experiment II, a future study could treat odor as a factor and fully power the experiment to account for potential differences in odor that could be obscured by counterbalancing.

CHAPTER IV

GENERAL DISCUSSION

The two experiments reported investigated whether global environmental context reinstatement effects are due to a shared context across study items or due to unique aspects of a rich environment being associated with each individual studied item. In Experiment I, the single cue of odor present during study was manipulated within a rich global environment to be either reinstated or changed during test. However, Experiment I found no evidence for context reinstatement effects. This result could not be attributed to the failure of a single cue to provide context for reinstatement because there were critical methodological problems identified in the experimental materials and procedure. Not only did the categorical word list overshadow the odor context at study by allowing for interitem associations to be formed, but also providing a categorical cue at retrieval outshone any potential use of the odor cue at retrieval. Additionally, the odors used may not have been distinctive enough to be perceived as separate from the office environment in which participants studied and were tested. Perhaps even more critical, because participants did not change rooms in the reinstatement condition, the odor context may not have been reinstated at all, particularly if participants adapted to the odor before the onset of the test phase.

Experiment II was designed to resolve these problems. The word lists were changed to consist of unrelated words with incidental encoding instructions, both of which discouraged interitem association among list words. The odors selected were distinctive from those typical to an office environment. Finally, a recovery method (Isarida et al., 2014) was modified to both address concerns with that procedure and to eliminate the potential for adaptation to the study odor and to actually reinstate the odor context by changing rooms.

This new procedure required a change to the strategy for answering the initial research question of whether the manipulation of a singular cue within a complex unchanging global environment would be sufficient to elicit context reinstatement effects. In Experiment II, the new strategy was to manipulate odor within a sparse global environment. The original research question was changed to ask whether a singular cue alone could elicit context reinstatement effects. If so, then perhaps it could be extrapolated that the global environment, although more complex, serves as a singular cue for all studied items, because in this case, the global environment was the odor. However, context reinstatement effects were not found.

One limitation of Experiment II was low power. The lack of power due to so many participants being excluded prevented strong conclusions of context reinstatement effects. It was necessary to exclude participants who could not pass the manipulation check questions, but it was also surprising that so many failed. Perhaps the odor presentation should have been stronger, or additional efforts should have been made to be certain of odor diffusion consistency between the study and test cubicles. However, it was also spring in Mississippi and allergies could have been to blame for the large number of participants who could not do odor discrimination. The fact that free recall was also quite low did nothing to help the power issues; there were very few words freely recalled across all experimental conditions. Certainly, the optimal situation would be to collect more data, but due to disruption of the pandemic, that was not possible.

A meta-analysis conducted by Smith and Vela (2001) suggested that global environmental context reinstatement effects are robust and reliable, with an average effect size of d = .28 for all studies. Smith and Vela (2001) suggested two guiding principles to follow when conducting context reinstatement research: 1) decrease the use of nonenvironmental cues at learning or at test 2) to decrease the extent to which participants can mentally reinstate the context. In Experiment I, at least one of these guiding principles was violated because the type of words learned increased the associative processing, and context reinstatement effects were not obtained. Adding odor to the design added the complexities of odor research by introducing problems with adaptation. These problems were fixed in Experiment II by creating an unrelated list, selecting distinctive odors, and using a recovery room to reinstate the context and allow for recovery from adaptation. Experiment II followed both guiding principles. However, because of a lack of power in the analysis, the ability to draw firm conclusions about whether a singular cue in a sparse global context is sufficient to serve as a cue for multiple targets.

The results hint that the entire global environmental context does not serves as a cue for all study items rather than different unique cues from within the global environment being associated with individual targets. The use of odor as the singular cue introduced additional complexities and whether odor is an effective global contextual environmental cue serves to elicit context reinstatement effects seems to depend on the odor selected, the diffusion of that odor, whether the odor is consistently perceived, and on whether people adapt to the odor before the test. Therefore, whether odor can function as an effective retrieval cue in a rich global environment to facilitate memory when reinstated is still in question. As stated by Bjork & Rickardson-Klavehn (1989), the relationship between environmental context and human memory is a puzzling one.

REFERENCES

Abernethy, E. M. (1940). The effect of changed environmental conditions upon the results of college examinations. *The Journal of Psychology*, 10, 293-301. https://doi.org/10.1080/00223980.1940.9917005

Ball, L. J., Shoker, J., & Miles, J. N. V. (2010). Odour-based context reinstatement effects with indirect measures of memory: The curious case of rosemary. *British Journal of Psychology*, 101, 655–678. https://doi.org/10.1348/000712609X479663

Bjork, R. A., & Richardson-Klavehn, A. (1989). On the puzzling relationship between environmental context and human memory. *In* C. Izawa (Ed.), *Current issues in cognitive processes: The Tulane Flowerree Symposium on Cognition* (pp. 313-344). Lawrence Erlbaum Associates, Inc.

Calkins, M. W. (1894). Experimental. *Psychological Review*, 1, 327-329. https://doi.org/10.1037/h0065852

Canas, J. J., & Nelson, D. L. (1986). Recognition and environmental context: The effect of testing by phone. *Bulletin of the Psychonomic Society*, 24, 407-409. https://doi.org/103758/BF03330565

Cann, A., & Ross, D. A. (1989). Olfactory stimuli as context cues in human memory. *The American Journal of Psychology*, 102, 91-102. https://www.jstor.org/stable/1423118

Castro, J. B., Ramanathan, A., & Chennubhotla, C. S. (2013). Categorical dimensions of human odor descriptor space revealed by non-negative matrix factorization. *PloS one*, 8, 1-16. https://doi.org/10.1371/journal.pone.0073289

Chu, S., & Downes, J. J. (2000). Odour-evoked autobiographical memories: Psychological investigations of Proustian phenomena. *Chemical Senses*, 25, 111-116. https://doi.org/10.1093/chemse/25.1.111

Dalton, P. (2000). Psychophysical and behavioral characteristics of olfactory adaptation. *Chemical Senses*, 25, 487-492. https://doi.org/10.1093/chemse/25.4.487

Dolinsky, R., & Zabrucky, K. (1983). Effects of environmental context changes on memory. *Bulletin of the Psychonomic Society*, 21, 423-426. https://doi.org/10.3758/BF03329998

Eakin, D. K. (2010). ListChecker Pro 1.2: A program designed to facilitate creating word lists using the University of South Florida word association norms. *Behavior Research Methods,* 42, 1012-1021. https://doi.org/10.3758/BRM.42.4.1012

Eichenbaum, H. (2001). The hippocampus and declarative memory: Cognitive mechanisms and neural codes. *Behavioural Brain Research*, 127, 199–207. https://doi.org/10.1016/S016604328(01)00365-5

Fernandez, A., & Glenberg, A. M. (1985). Changing environmental context does not reliably affect memory. *Memory & Cognition*, 13, 333-345. https://doi.org/103758/BF03202501

Finch, D., Carvalho, P. F., & Goldston, R. L. (2016). Variability in category learning: The effect of context change and item variability on knowledge generalization. *In* A. Papafragou, D. Grodner, D. Mirman, & J.C. Trueswell (Eds.), *Proceedings of the 38th Annual Conference of the Cognitive Science Society* (pp.2327-2332). Austin TX: Cognitive Science Society.

Glenberg, A. M. (1979). Component-levels theory of the effects of spacing of repetitions on recall and recognition. *Memory & Cognition*, 7, 95-112. https://doi.org/10.3758/BF03197590

Godden, D. R., & Baddeley, A. D. (1975). Context-dependent memory in two natural environments: On land and Underwater. *British Journal of Psychology*, 66, 325-331. https://doi.org/10.1111/j.2044-8295.1975.tb01468.x

Herz, R. S. (1997). The effects of cue distinctiveness on odor-based context-dependent memory. *Memory & Cognition*, 25, 375-380. https://doi.org/10.3758/BF03211293

Herz, R. S. (2016). The role of odor-evoked memory in psychological and physiological health. *Brain Sciences*, 6, 1-13. https://doi.org/10.3390/brainsci6030022

Herz, R.S., & Cupchik, G. C. (1992). An experimental characterization of odor-evoked memories in humans. *Chemical Senses*, 17, 519-528. https://doi.org/10.1093/chemse/17.5.519

Herz, R. S., & Engen, T. (1996). Odor memory: Review and analysis. *Psychonomic Bulletin & Review*, 3, 300–313. https://doi.org/10.3758/BF03210754

Isarida, T. (2005). Study-time effect on free recall within and out of context. *Memory*, 13, 785-795. https://doi.org/10.1080/09658210500139218

Isarida, T. & Isarida, T. K. (2004). Effects of environmental context manipulated by the combination of place of place and task on free recall. *Memory*, 12, 376-384. https://doi.org/10.1080/09658210344000062

Isarida, T., & Isarida, T. K. (2007). Environmental context effects of background color in free. *Memory & Cognition*, 35, 1620-1629. https://doi.org/10.3758/BF03193496

Isarida, T., Sakai, T., Kubota, T., Koga, M., Katayama, Y., & Isarida, T. K. (2014). Odor-context effects in free recall after a short retention interval: A new methodology for controlling adaptation. *Memory & cognition*, 42, 421-433. https://doi.org/10.3758/s13421-013-0370-1

Laird, D. A. (1935). What can you do with your nose?. *The Scientific Monthly*, 41, 126-130. https://www.jstor.org/stable/16002

Murnane, K., & Phelps, M. P. (1993). A global activation approach to the effect of changes in environmental context on recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 19, 882-894. https://doi.org/10.1037/0278-7393.19.4.882

Murnane, K., & Phelps, M. P. (1994) When does a different environmental context make a difference in recognition? A global activation model. *Memory & Cognition*, 22, 584-590. https://doi.org/10.3758/BF03198397

Nelson, D. L., McEvoy, C. L., & Schreiber, T. A. (1998). The University of South Florida word association, rhyme, and word fragment norms. http://www.usf.edu./freeassociation/

Nelson, D. L., McEvoy, C. L., & Schreiber, T. A. (2004). The University of South Florida word association, rhyme, and word fragment norms. *Behavior Research Methods, Instruments, & Computers*, 36 402-407. https://doi.org/10.3758/BF03195588

Parker, A., & Gellatly, A. (1997). Moveable cues: A practical method for reducing context-dependent forgetting. *Applied Cognitive Psychology*, 11, 163-173. https://doi.org/10.1002/(SICI)1099-0720(199704)11:2<163::AID-ACP427>3.0.CO;2-1

Parker, A., Ngu, H., & Cassaday, H. J. (2001). Odour and Proustian memory: reduction of context-dependent forgetting and multiple forms of memory. *Applied Cognitive Psychology*, 15, 159-171. https://doi.org//10.1002/1099-0720(200103/04)15:2<159::AID-ACP694>3.0.CO;2-D

Pointer, S. C., & Bond, N. W. (1998). Context-dependent Memory: Colour versus Odour. *Chemical Senses*, 23, 359–362. https://doi.org/10.1093/chemse/23.3.359

Postman, L. (1971). Organization and interference. *Psychological Review*, 78, 290-302. https://doi.org/10.1037/h0031031

R Core Team (2019). R: A language and environment for statistical computing. *R Foundation for Statistical Computing*, Vienna, Austria. https://www.R-project.org/

Raaijmakers, J. G., & Shiffrin, R. M. (1981). Search of associative memory. *Psychological Review*, 88, 93-134. https://doi.org/10.1037/0033-295X.88.2.93

Rubin, D. C., Groth, E., & Goldsmith, D. J. (1984) Olfactory cuing of autobiographical memory. *The American Journal of Psychology*, 97, 493-507. https://www.jstor.org/stable/1422158

Sakai, T., Isarida, T. K., & Isarida, T. (2010). Context-dependent effects of background colour in free recall with spatially grouped words. *Memory*, 18, https://doi.org/10.1080/09658211.2010.508748

Saufley, W. H., Otaka, S. R., & Bavaresco, J. L. (1985). Context effects: Classroom tests and context independence. *Memory & Cognition*, 13, 522-528. https://doi.org/10.3758/BF03198323

Schab, F. R. (1990). Odors and the remembrance of things past. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 16, 648-655. https://doi.org/10/1037/0278-7393.16.4.648

Smith, S. M. (1979). Remembering in and out of context. *Journal of Experimental Psychology: Human Learning and Memory*, 5(5), 460-471. https://doi.org/10.1037/0278-7393.5.5.460

Smith, S. M. (1982). Enhancement of recall using multiple environmental contexts during learning. *Memory & Cognition*, 10, 405-412. https://doi.org/10.3758/BF03197642

Smith, S. M. (1988). Environmental context-dependent memory. *In* G.M. Davies, & D.M Thomson (Eds.), *Memory in context: Context in memory* (pp. 13-34). John Wiley & Sons.

Smith, S. M. (1994). Theoretical principles of context-dependent memory. In M.M. Gruneberg & P.E. Morris (Eds.), *Theoretical Aspects of Memory* (2nd ed., pp.168-195). Routledge.

Smith, S. M. (2013). Effects of Environmental Context on Human Memory. In T.J. Perfect (Eds.), *The SAGE Handbook of Applied Memory* (pp. 162-182). SAGE Publication Ltd.

Smith, D. G., & Standing de Man, L. (1992). Verbal memory elicited by ambient odor. *Perceptual and Motor Skills*, 74, 339-343. https://doi.org/10.2466/pms.1992.74.2.339

Smith, S. M., Glenberg, A., & Bjork, R. A. (1978). Environmental context and human memory. *Memory & Cognition*, 6(4), 342-353. https://doi.org/10.3758/BF03197465

Smith, S. M., & Handy, J. D. (2014). Effects of varied and constant environmental contexts on acquisition and retention. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 40, 1582-1593. https://doi.org/10.1037/xlm0000019

Smith, S. M., & Manzano, I. (2010). Video context-dependent recall. *Behavior Research Methods*, 42, 292-301. https://doi.org/10.3758/BRM.42.1.292

Smith, S. M., & Rothkopf, E. Z. (1984). Contextual enrichment and distribution of practice in the classroom. *Cognition and Instruction*, 1, 341-358. https://doi.org/10.1207/s1532690xci0103_4

Smith, S. M., & Sinha, A. K. (1987). *Effect of brief immersion in a flotation tank on memory and cognition* (Tech. Rep. No. CSCS-004). College Station, TX: Texas A&M Univeristy, Committee for the study of Cognitive Science.

Smith, S. M., & Vela, E. (1992). Environmental context-dependent eyewitness recognition. *Applied Cognitive Psychology*, 6, 125-139. https://doi.org/10.1002/acp.2350060204

Smith, S. M., & Vela, E. (2001). Environmental context-dependent memory: A review and meta-analysis. *Psychonomic Bulletin & Review*, 8, 203–220. https://doi.org/10.3758/BF03196157

Stuck, B. A., Fadel, V., Hummel, T., & Sommer, J. U. (2013). Subjective olfactory desensitization and recovery in humans. *Chemical Senses*, 39, 151-157. https://doi.org/10.1093/chemse/bjt064

Tham, W. W. P., Stevenson, R. J., & Miller, L. A. (2009). The functional role of the medio dorsal thalamic nucleus in olfaction. *Brain Research Reviews*, 62, 109–126. https://doi.org/10.1016/j.brainresrev.2009.09.007

Tulving, E., & Pearlstone, Z. (1966). Availability versus accessibility of information in memory for words. *Journal of Verbal Learning and Verbal Behavior*, 5, 381-391. https://doi.org/10.1016/S0022-5371(66)80048-8

Tulving, E., & Thomson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review*, 80, 352-373. https://doi.org/10.1037/h0020071

Van Overschelde, J. P., Rawson, K. A., & Dunlosky, J. (2004). Category norms: An updated and expanded version of the Battig and Mantague (1969) norms. *Journal of Memory and Language*, 50, 289-335. https://doi.org/10.1016/j.jml.2003.10.003

Watkins, O. C., & Watkins, M. J. (1975). Buildup of proactive inhibition as cue-overload effect. *Journal of Experimental Psychology: Human Learning and Memory*, 1, 442-452. https://doi.org/10.1037/0278-7393.1.4.442

Wright, D. L., & Shea, C. H. (1991) Contextual dependencies in motor skills. *Memory & Cognition*, 19, 361-370. https://doi.org/10.3758/BF03197140

APPENDIX A

WORD LISTS

Table A1 *Experiment I List One*

Category	Word	Probability of Response	Average Per Category
Precious Stones	Topaz	.12	.17
	Gold	.14	
	Opal	.18	
	Amethyst	.18	
	Pearl	.22	
Types of Fabric	Suede	.08	.10
	Jean	.08	
	Velvet	.10	
	Fleece	.11	
	Linen	.12	
Kitchen Utensils	Plate	.13	.14
	Ladle	.14	
	Bowl	.14	
	Blender	.14	
	Whisk	.15	
Articles of Furniture	Stool	.11	.13
	Recliner	.12	
	Ottoman	.12	
	Nightstand	.13	
	Lamp	.17	
Parts of the human body	Wrist	.07	.09
	Teeth	.07	
	Tongue	.10	
	Lung	.10	
	Ankle	.10	
Fruits	Lime	.11	.13
	Raspberry	.12	
	Cantaloupe	.14	
	Blueberry	.14	
	Cherry	.15	
Weapons	Hammer	.06	.07
	Club	.06	
	Pistol	.08	
	Missile	.08	
	Mace	.09	
Types of human dwellings	Tepee	.11	.15
	Trailer	.13	
	Townhouse	.15	
	Tent	.19	

Title A1 (continued)

Category	Word	Probability of Response	Average Per Category
Types of human dwellings	Hut	.19	
Average for list			.12

Table A2 *Experiment I List Two*

Category	Word	Probability of Response	Average Per Category
Carpenter's tools	Wood	.11	.16
	Ruler	.12	
	Level	.13	
	Wrench	.20	
	Drill	.23	
Substances for flavoring food	Vinegar	.08	.10
	Onion	.08	
	Mustard	.10	
	Vanilla	.11	
	Basil	.11	
Occupations	Manager	.09	.11
	Secretary	.10	
	Engineer	.10	
	Dentist	.12	
	Accountant	.13	
Sports	Polo	.07	.09
	Gymnastics	.08	
	Running	.09	
	Cheerleading	.13	
	Skiing	.11	
Articles of clothing	Sweatshirt	.17	.18
	Gloves	.17	
	Dress	.19	
	Coat	.19	
	Jeans	.20	
Chemical elements	Lithium	.08	.09
	Boron	.08	
	Aluminum	.08	
	Calcium	.09	
	Neon	.10	
Musical instruments	Keyboard	.09	.10
	Horn	.09	

Table A2 (continued)

Category	Word	Probability of Response	Average Per Category
Musical instruments	Harp	.10	
	Viola	.12	
	Bass	.12	
Birds	Finch	.08	.09
	Duck	.08	
	Penguin	.09	
	Ostrich	.09	
	Raven	.09	
Average for list			.11

Table A3 *Experiment II List One*

Word
Feed
Spring
Captain
Square
Murder
Election
Station
Patient
Sound
Teeth
Window
Hold
Boys
Artist
Sleep
Dress
Post
Walk
Dictionary
Youth
Test
Fear
Lower
Price

Table A4 *Experiment II List Two*

Word
Steps
Officer
Ground
Famous
Language
Division
Daily
Stay
Horse
Radio
Buy
Private
Murder
Son
Picture
Friends
Final
Sweet
Story
Temperature
Ship
King
Thin
Lips

APPENDIX B

DIGITAL CONSENT FORMS

Experiment I

Press ENTER to begin consent process.

Overview

You are being asked to be a volunteer in a research study. The purpose of the consent process is to tell you about the study you will be participating in today and to inform you about your rights as a research volunteer. Before you participate, you should read the consent screens carefully and completely. Thank you for volunteering to participate in this study. Our work could not be done without your help and willingness to give of your time and yourself. If at any point you do not wish to continue the consent process, please raise your hand to inform the researcher. Press ENTER to continue.

Purpose and Procedure

The purpose of this research is to test how well people are able to remember a list of words for a memory test. If you decide to participate in this study, you will be asked to study a list of words on a computer monitor. Then, you will be asked to complete a problem solving task. Finally, you will recall the words from the list that you studied. At each stage, you will be given instructions to make sure you know what you are supposed to do throughout the study. The word lists will be presented on a desktop computer screen and you will make all of your responses using a keyboard. The study should take approximately 1 hour. Press ENTER to indicate that you understand the purpose and procedure of this study.

Risks or Discomforts

There are no major physical discomforts involved in this study. Risks are minimal and do not exceed those of normal office work. Please tell us if you are having trouble with any task or if you need additional rest and the investigator will be happy to accommodate you in any way possible. If you feel any discomfort, please tell the person assisting you immediately. Press ENTER to indicate you understand the risks or discomforts of this study.

Incentive to participate

This study will take approximately 1 hour, and you will be reimbursed for your participation. Student participants will receive 1/2 research credit for every halfhour of participation. We want you to know, however, that you are free to change your mind and withdraw from this research at any time. There will be no penalty for doing so. You will receive compensation equal to the time involved in the study. However, students will receive no less than 1/2 of a research credit. Press ENTER to indicate you understand the incentive to participate in this study.

Confidentiality

All of your responses will be kept strictly confidential. To protect the confidentiality of this information, we will assign you a data code number that will only be known to the members of the research project. All of the information which you provide us today will be marked with the code number, not your name. All information will be stored in a computer for analysis using only your code number for identification. No indication of your individual answers to questions will be given to anyone. We want you to be completely confident that you may feel free to answer all questions without concern that it may affect you in any way. Your name and identifying information will not be connected in any way to your responses in this study. The online system will automatically grant you credit when you submit your responses by separately submitting your PRP Identity Code back to the SONA system while your responses are sent to a different database for retrieval by the researcher. If you are participating in a lab study (in-person research), be sure to bring your “Identity Code” (available under the “My Profile” tab on the PRP website) with you to the study, so that you may be granted credit. Please note that these records will be held by a state entity and therefore are subject to disclosure if required by law. Research information may be shared with the MSU Institutional Review Board (IRB) and the Office for Human Research Protections (OHRP). Press ENTER to indicate that you understand the confidentiality policy of this study.

Questions

If you have any questions about this research project, please feel free to contact Dustin Finch at df979@msstate.edu or Dr. Deborah Eakin at de115@msstate.edu. For questions regarding your rights as a research participant, or to discuss problems, express concerns or complaints, request information, or offer input, please feel free to contact the MSU Research Compliance Office by phone at 662-325-3994, by e-mail at irb@research.msstate.edu, or on the web at http://orc.msstate.edu/humansubjects/participant/. Press ENTER to indicate that you understand your options if you have any questions.

Voluntary Participation

Please understand that your participation is voluntary. Your refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may discontinue your participation at any time without penalty or loss of benefits. Press ENTER to indicate that you understand that your participation is voluntary.

Press ENTER to indicate that you have read the consent information on the previous screens and that you agree to participate in this research study.

Experiment II

Press ENTER to begin consent process.

Overview

You are being asked to be a volunteer in a research study. The purpose of the consent process is to tell you about the study you will be participating in today and to inform you about your rights as a research volunteer. Before you participate, you should read the consent screens carefully and completely. Thank you for volunteering to participate in this study. Our work could not be done without your help and willingness to give of your time and yourself. If at any point you do not wish to continue the consent process, please raise your hand to inform the researcher. Press ENTER to continue.

Purpose and Procedure

The purpose of this research is to better understand certain characteristics of words for a future study. You will rate a list of words for their pleasantness. If you decide to participate in this study, you will be asked to rate a list of words as Unpleasant, Neutral, or Pleasant on a computer monitor. Then, you will be asked to complete a problem solving task in a separate room. Finally, you will be moved to a third room where you will complete a post experimental survey about the list of words. At each stage, you will be given instructions to make sure you know what you are supposed to do throughout the study. The word lists will be presented on a desktop computer screen and you will make all of your responses using a keyboard. The study should take approximately 1 hour. Press ENTER to indicate that you understand the purpose and procedure of this study.

Risks or Discomforts

There are no major physical discomforts involved in this study. Risks are minimal and do not exceed those of normal office work. Please tell us if you are having trouble with any task or if you need additional rest and the investigator will be happy to accommodate you in any way possible. If you feel any discomfort, please tell the person assisting you immediately. Press ENTER to indicate you understand the risks or discomforts of this study.

Incentive to participate

This study will take approximately 1 hour, and you will be reimbursed for your participation. Student participants will receive 1/2 research credit for every halfhour of participation. We want you to know, however, that you are free to change your mind and withdraw from this research at any time. There will be no penalty for doing so. You will receive compensation equal to the time involved in the study. However, students will receive no less than 1/2 of a research credit. Press ENTER to indicate you understand the incentive to participate in this study.

Confidentiality

All of your responses will be kept strictly confidential. To protect the confidentiality of this information, we will assign you a data code number that will only be known to the members of the research project. All of the information which you provide us today will be marked with the code number, not your name. All information will be stored in a computer for analysis using only your code number for identification. No indication of your individual answers to questions will be given to anyone. We want you to be completely confident that you may feel free to answer all questions without concern that it may affect you in any way. Your name and identifying information will not be connected in any way to your responses in this study. The online system will automatically grant you credit when you submit your responses by separately submitting your PRP Identity Code back to the SONA system while your responses are sent to a different database for retrieval by the researcher. If you are participating in a lab study (in-person research), be sure to bring your “Identity Code” (available under the “My Profile” tab on the PRP website) with you to the study, so that you may be granted credit. Please note that these records will be held by a state entity and therefore are subject to disclosure if required by law. Research information may be shared with the MSU Institutional Review Board (IRB) and the Office for Human Research Protections (OHRP). Press ENTER to indicate that you understand the confidentiality policy of this study.

Questions

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Voluntary Participation

Please understand that your participation is voluntary. Your refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may discontinue your participation at any time without penalty or loss of benefits. Press ENTER to indicate that you understand that your participation is voluntary.

Press ENTER to indicate that you have read the consent information on the previous screens and that you agree to participate in this research study.

APPENDIX C

EXPERIMENT II POST-EXPERIMENTAL QUESTIONAIRRE

Questions

One

Did you notice anything about the experiment that you would like to comment on? Please answer yes or no in the space provided below and provide your comments.

Two

What were the differences you noticed, if any? Type your answer below and then hit SHIFT-8 to continue to the next question.

Three

Are you suffering from a cold or allergies that make smelling difficult today? Type your answer below and then hit SHIFT-8 to continue to the next question.

Four

Is there any other reason why you are unable to smell today? Type your answer below and then hit SHIFT-8 to continue to the next question.

APPENDIX D

IRB APPROVAL LETTER

MISSISSIPPI STATE UNIVERSITY

Office of Research Compliance

Institutional Review Board for the Protection of
Human Subjects in Research
P.O. Box 6223
53 Morgan Avenue
Mississippi State, MS 39762
P. 662.325.3294

www.orc.msstate.edu

NOTICE OF DETERMINATION FROM THE HUMAN RESEARCH PROTECTION PROGRAM

DATE:	October 23, 2018
TO:	Deborah Eakin, PhD, Psychology, Dustin Finch
PROTOCOL TITLE:	Remembering Categories
PROTOCOL NUMBER:	IRB-18-468
	Approval Date: October 23, 2018 Expiration Date: October 22, 2023

EXEMPTION DETERMINATION

The review of your research study referenced above has been completed. The HRPP had made an Exemption Determination as defined by 45 CFR 46.101(b)2. Based on this determination, and in accordance with Federal Regulations, your research does not require further oversight by the HRPP.

Employing best practices for Exempt studies are strongly encouraged such as adherence to the ethical principles articulated in the Belmont Report, found at www.hhs.gov/ohrp/regulations-and-policy/belmont-report/# as well as the MSU HRPP Operations Manual, found at www.orc.msstate.edu/humansubjects. Additionally, to protect the confidentiality of research participants, we encourage you to destroy private information which can be linked to the identities of individuals as soon as it is reasonable to do so.

Based on this determination, this study has been inactivated in our system. This means that recruitment, enrollment, data collection, and/or data analysis **CAN** continue, yet personnel and procedural amendments to this study are no longer required. **If at any point, however, the risk to participants increases, you must contact the HRPP immediately. If you are unsure if your proposed change would increase the risk, please call the HRPP office and they can guide you.**

If this research is for a thesis or dissertation, this notification is your official documentation that the HRPP has made this determination.

If you have any questions relating to the protection of human research participants, please contact the HRPP Office at irb@research.msstate.edu. We wish you success in carrying out your research project.

Review Type:	EXEMPT
IRB Number:	IORG0000467