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A novel use of the Deese-Roediger-McDermott Paradigm: Distinguishing between differential memory mechanisms in emotional literature

Alan John Yablonski Jr.
James Madison University

A Novel Use of the Deese-Roediger-McDermott Paradigm: Distinguishing Between Differential Memory Mechanisms in Emotional Literature

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FACULTY COMMITTEE:

Project Advisor: Kethera A. Fogler, Ph.D.,
Assistant Professor, Psychology

Reader: Bryan K. Saville, Ph.D.,
Professor, Psychology

Reader: Janna Taft Young, Ph.D.,
Adjunct Professor, Psychology

HONORS PROGRAM APPROVAL:

Bradley R. Newcomer, Ph.D.,
Director, Honors Program

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Abstract

To current knowledge, the emotional literature has not included the proposal to conceptualize experimental designs in terms of item vs. hippocampal-dependent relational memory representations. Through utilizing the Deese-Roediger-McDermott (DRM) paradigm the current study targets two memory mechanisms: item-specific memory (i.e., font color) and relational memory. In addition, relational-binding memory was also assessed. The current study consists of three hypotheses: (a) negatively-valenced critical lures will be correctly recalled by participants more than neutrally-valenced critical lures (increased relational memory for negatively-valenced words), (b) participants will more accurately recall studied negatively-valenced words with the correct color compared to neutrally-valenced studied words (increased item-specific memory for negative words), and (c) participants will less likely accurately recall negative critical lures with their correct color compared to neutral critical lures (decreased relational-binding memory for negative words). Both neutrally and negatively-valenced word lists were organized under a non-studied overarching theme (critical lure), and were counterbalanced according to the font color of the word. Once participants viewed each word list during the study phase, they participated in a recognition test in order to determine whether these two memory mechanisms were enhanced for negatively-valenced word lists compared to neutrally-valenced word lists. Results were consistent with the hypotheses in that, participants had increased relational and item-specific memory for negative words yet decreased relational-binding memory for negative words.

Keywords: emotion, memory, relational memory, item-specific, DRM paradigm

A Novel Use of the Deese-Roediger-McDermott Paradigm: Distinguishing Between Differential Memory Mechanisms in Emotional Memory

People rely on the accuracy of their memory for many basic events, such as remembering to meet with a friend, to go to a meeting, and even to remember material on an upcoming exam or business plan speech. However, what if memory was not as accurate as it is perceived to be? How would these impact life-changing situations that depended on an accurate account of memory, such as legal cases, sexual and childhood abuse, and eye-witness testimonies? In these circumstances, memory is subject to very intense, emotional stimuli that might have an effect on cognitive processes.

In any research investigation on a topic as abstract as memory, it is crucial to discuss how the term has been traditionally understood and defined. What is meant by the term "memory"? Memory is commonly defined as that which is remembered, or the faculty by which the mind stores and retrieves information (Underwood, 1969). The idea of Underwood's associationism can help distinguish the foundation of memory. In its simplest form, associationism states that mental representations that are associated are connected in cognitive networks, such that the activation of one representation will activate an associated representation (Underwood, 1969). The basic idea is that information is stored in nodes (cognitive units of information) and organized according to semantic, lexical, and phonological systems. Within this structure, spreading activation occurs in which nodes that are associated are more closely connected, and activation of one closely related concept will activate or prime (meaning to prepare for activation) another closely related concept (Lerner, Bentin, & Shriki, 2012).

Regarding emotional memory, people tend to believe that they have an easier time remembering emotional experiences, such as a negative memory being easier to recall than a

non-emotional memory. This is similar to the commonly known "weapon-focus" effect, which is the circumstance in which a witness of a crime will more likely remember the weapon used by the criminal but not peripheral information such as the description of the criminal's facial features (Loftus, 1979). However, the current emotional memory research has only found inconsistent results concerning the true implications emotion has on accurate memory. Some researchers (Mackay & Ahmetzanov, 2005; Mather & Nesmith, 2008; Rimmele, Davachi, Petrou, Dougal, & Phelps, 2011) have found that memory recall was enhanced with the presentation of emotional stimuli, while other's findings have shown opposing results that emotional stimuli can actually impair memory (Mather & Knight, 2008; Mather et al., 2006; Pierce & Kensinger, 2011). Moreover, other researchers have found that these results can be conditional on many other factors, such as if the stimulus is a picture or a word, and in what medium the contextual information is depicted (Christianson, Loftus, Hoffman, & Loftus, 1991; Kensinger, Garoff-Eaton, & Schacter, 2006; Sharot & Yonelinas, 2008). Before going into the current experiment's details, it would be useful to examine more closely these conflicting findings regarding the role of emotion on memory in the past literature.

Inconsistent Results on Emotional Memory for Relational Information

Previous research on the effects of emotion on memory for relational information shows inconsistent results, with some studies finding enhanced memory for relational information—such as enhanced memory of color information associated with emotional words or scenes (Doersken & Shimamura, 2001; D'Argembeau & Van der Linden, 2005; MacKay & Ahmetzanov, 2005), enhanced memory of screen location of negative arousing scenes (Mather & Nesmith, 2008), and improved memory for temporal order of emotional items within a list (Schmidt, Patnaik, & Kensinger, 2011). Prior literature incorporates many different designs and

memory mechanisms while analyzing emotion's effects on memory. For instance, Doerksen and Shimamura (2001), Mackay and Ahmetzanov (2005), D'Argembeau and Van der Linden (2004), Mather and Nesmith (2008), and Schmidt et al. (2011) analyzed emotional memory by incorporating source memory studies in their research and found consistent results that emotional stimuli enhance memory. However, each study's methods varied quite drastically in the methodology and operational definitions of memory and emotion, with some utilizing word-color and word-color frame pairings as their stimuli and others using word-location, picture-location, or temporal ordering as their emotional and neutral stimuli presented to their participants.

Word-color and word-color-frame pairings are quite common in this genre of research, and Doerksen and Shimamura (2001) showed that emotional words enhanced source memory. In particular, memory for the word's font color was more enhanced for emotional words compared to neutral words. Additionally, Doerksen and Shimamura found that emotional words also enhanced free recall. Moreover, word-color and word-location pairings were utilized by D'Argembeau and Van der Linden (2005) in order to examine whether the influence of emotion extends to episodic memory and temporal stimuli. After incorporating a list-discrimination paradigm in which participants were successively presented with three study lists, each containing positive, negative, or neutral pictures, the researchers asked participants to differentiate the old pictures from an assortment of new pictures. They found that item-memory recall was enhanced for both negative and positive pictures compared to neutral pictures. In particular, memory was more accurate for negative pictures than for positive ones.

In order to test this relational memory while following the methodology of word-location studies, Mackay and Ahmetzanov (2005) utilized a version of the Stroop Color-naming task in

which the emotional event of interest was taboo words located in different screen areas and participants were to name the font color of taboo words and neutral words. In one condition, several words' locations remained consistent so the words always occupied the same screen location, but in the second condition, instead of the words being location-consistent, several colors were location-consistent. The researchers found improved recognition accuracy for taboo words compared to neutral words. In addition, there was more accurate recognition in the color-location condition than in the word-location condition. Moreover, there was improved location recognition for taboo words versus neutral words in the word-location condition. These findings were not, however, found in the color-location condition. These results support the binding hypothesis that emotional reactions can cause binding mechanisms that act as a connector for a specific source of an emotion to salient contextual aspects such as location. In this particular experiment, word-specific emotional reactions to a particular taboo word enhanced memory for contextual information directly connected with that word, but not with contextual aspects that were indirectly associated with taboo words.

Consistent with the findings of Mackay and Ahmetzanov (2005), previous literature has found that there tends to be increased memory for characteristics of emotional items that supports the idea that there is an interference effect occurring during the simultaneous presentation of both emotional and neutral stimuli. Due to this, emotionally-arousing stimuli can interfere with memory for spatially or temporally nearby neutral items. In order to test if this binding hypothesis effect is also found when utilizing pictures instead of words, Mather and Nesmith (2008) conducted a picture-location experiment in which participants completed a forced-choice memory test for the picture-location conjunctions after an incidental encoding session. From these results the researchers concluded that participants remembered the location

of emotionally-arousing pictures more efficiently than the location of neutral pictures. Finally, Schmidt et al. (2011) found that emotion can improve memory for contextual information through the use of scene locations within an ordered list presented to participants. Because information encoded in episodic memory is categorized in a spatial and temporal context, they examined whether an item's valence or arousal would affect its chance of being remembered with those contextual stimuli. Their results supported their hypothesis that emotionally-arousing items in spatial and temporal context resulted in more accurate memory than neutral items. Although valence did not influence recall or recognition, positive high-arousal stimuli elicited enhanced memory compared to negative stimuli.

However, other research implies impaired memory for relational information—such as less detailed memory for scene contexts that form the background for centrally presented emotional items (Kensinger et al., 2007), impaired memory for cognitive tasks performed on items (Cook, Hicks, & Marsh, 2007; Kensinger & Schacter, 2006) for relations of objects superimposed on emotional scenes (Rimmele, Davachi, Petrov, Dougal, & Phelps, 2011; Touryan, Marian, & Shumamura, 2007), and for relational bindings between item pairs (Mather & Knight, 2008; Pierce & Kensinger, 2011). Again, the numerous researchers who have found impaired memory for emotional stimuli have also implemented various types of memory study designs and have differed in their analysis of opposing memory mechanisms. For example, source memory studies (Kensinger & Schacter, 2006; Cook et al., 2007; Rimmele et al., 2011; and Mather & Knight, 2008), scene context studies (Christianson, Loftus, Hoffman, & Loftus, 1991; Touryan et al., 2007), and paired designs (Pierce & Kensinger, 2011; Mather & Knight, 2008) have all found impaired results of emotion on memory but have simultaneously and clearly varied in their methodology. Similar to the emotion enhancing memory literature, the

above mentioned researchers have varied in the categories of stimuli utilized, which vary from: word, picture-tasks (Kensinger & Schacter, 2006), word-tasks (Cook et al., 2007), scene-color frames (Rimmele et al., 2011), scene-locations (Mather et al., 2006), and face-locations (Mather and Knight, 2008) to studies in which the emotional item is embedded in a scene, causing impaired detailed memory for the scene (Christianson et al., 1991) and those in which neutral peripheral objects were embedded in emotional scenes and later binding of scene-object pairings was impaired (Touryan et al., 2007; Christianson et al., 1991); and finally to more simple paired designs such as word-word pairs (Pierce and Kensinger, 2011) and sound-digit pairings (Mather & Knight, 2008).

In a source memory study incorporating word-picture tasks, Kensinger and Schacter (2006) examined the link between amygdala activity and subsequently strong memory for both positive and negative information. In particular, they were concerned about the debate on whether amygdala activity at encoding corresponds with enhanced memory for all contextual aspects of the emotional stimuli, or whether amygdala activity primarily enhances memory for the emotional stimuli. They found that amygdala activity at encoding was related to subsequent memory for the positive and negative items but not to subsequent memory for the task performed. Moreover, amygdala activity showed no relationship to subsequent-memory performance for the neutral items. In addition, regardless of the emotional content of the stimulus, activity in the entorhinal cortex corresponded with subsequent memory for the item but not with memory for the task performed, whereas hippocampal activity corresponded with subsequent memory for the task performed.

Through another source memory experiment which differed in the presented stimuli (scene-color frame), Rimmele, Davachi, Petrov, Dougal, and Phelps (2011) hypothesized that

emotional scenes will cause an increased sense of remembering but an impaired recovery of contextual details and a defective association between contextual details and the main scene or event. Participants were tasked with judging whether the frame color-scene pairings were the same as the ones seen during the study phase. Their results were consistent with their hypotheses in that participants required a longer time to judge whether the color of the frame appeared in the negative scenes compared to the neutral scenes. So, correct identification of the pairings of the frame color and scene was significantly more accurate for colors that had framed neutral scenes than for colors that had framed negative scenes.

In addition, scene context studies have also found impaired memory for emotional content, such as in Kensinger et al. (2007), in which they examined whether trade-offs between the ability to remember the central emotional elements of an event versus the peripheral (non-emotional) elements of that same event, interact with one another when participants study scenes that elicit an emotional response due to the inclusion of a negatively valenced stimuli. After their memory was tested for the gist and visual detail of the stimulus and the background the researchers found that there was a memory trade-off for central emotional versus peripheral non-emotional elements of scenes. Similarly, scene context studies incorporating a neutral peripheral object embedded in a scene was tested by Touryan, Marian, and Shimamura (2007). In their experiment, they further observed the effects of emotion on memory for associations between item and peripheral information. Specifically, they wished to examine the influence of emotion on associative memory when the events had peripheral information that was simultaneously, spatially, and conceptually separate from the central-item information. Participants were given memory tests for the content of the picture (the central information), as well as the peripheral object information and the overall association between the picture and the peripheral

information. Their results supported their hypothesis that remembering of negative pictures would be better than neutral pictures; in contrast, they also found that memory for associations between item and peripheral information was decreased when the item information was negative as opposed to neutral information.

Furthermore, paired design experiments by Mather and Knight (2008) further explored the idea of emotional stimuli negatively affecting the performance of associative binding. Their particular research has been conducted to understand how anticipating an emotional effect can affect memory. In order to measure relational memory, Mather and Knight studied emotion in relation to the harbinger effect by testing whether memory was improved or impaired for digits presented simultaneously as neutral auditory tones that were previously paired with negative pictures. During the cue-learning phase, neutral tones were constantly paired with negative pictures while other neutral tones were conditioned with neutral pictures. Researchers then presented the tone and asked the participants to select which digits were paired with the tone. They found that memory for sound-digit pairings was impaired for sounds that previously predicted negative stimuli compared to sounds that previously predicted neutral stimuli (Mather & Knight). Moreover, these findings were consistent with the underlying concept of the emotional harbinger effect in which memory for contextual info associated with neutral cues that were conditioned with negative stimuli tends to be later impaired.

Finally, other studies simply find no differences in memory for relational information for emotional vs. neutral stimuli in both source memory studies (Sharot & Yonelinas, 2008) and paired design experiments (Sharot & Phelps, 2004). To specifically link memory enhancement of arousing material to modulation of memory retention, they examined recognition of neutral and arousing words at two different time periods and under conditions that manipulate attention

during encoding. Participants were briefly presented with an arousing or neutral word at the periphery, while fixating on a central word. Recognition of peripheral words was assessed either immediately or after a one day delay. Whereas recognition of neutral words became worse over time, recognition of arousing words remained the same and was better than neutral word recognition at delay. The results indicate that arousal supports slower forgetting even when the difference in attentional resources allocated to stimuli is minimized.

Why the Inconsistent Results?

According to Chiu and researchers (2013), emotional relational memory studies vary in the modality and informational structure of the contents under examination. Because of this, inconsistencies among studies is caused by different types of relational information being studied, and as a result, differences in the memory representations that each researcher tests. Thus, there are two necessary types of information that need to be distinguished to clarify these conflicting results. The first is contextual information, such as previously studied background scenes and objects shown with emotional stimuli. The second is relational binding content, which can include associations between semantically related content. One source of the inconsistencies in emotional memory literature is that the research sometimes focuses too much on the recollection of individual stimuli in isolation. Instead, researchers should concentrate on studying memory for stimuli in the context of, or in relation to, other items (Chiu et al., 2013).

However, this solution still produces inconsistent results, in which there is an enhancing effect of emotion on memory for individual stimuli, while results on the effects of emotion on memory for simultaneous contextual and relational items have been inconsistent between two results. The first result is enhanced relational memory for emotional stimuli (Doerksen & Shimamura, 2001; Mackay & Ahmetzanov, 2005; D'Argembeau & Van der Linden, 2004;

Mather & Nesmith, 2008; Schmidt et al., 2011) and the second is impaired relational memory for emotional stimuli (Kensinger & Schacter, 2006; Cook et al., 2007; Rimmele et al., 2011; Mather & Knight, 2008; Christianson, Loftus, Hoffman, & Loftus, 1991; Touryan et al., 2007; Pierce & Kensinger, 2011; Mather & Knight, 2008). Chiu and colleagues (2013) offer two solutions to this predicament. Firstly, they perceive that an organized categorization of which memory mechanisms are being studied is necessary to clarify the confusing results. Secondly, they believe it is necessary to consider and differentiate the simultaneous engagement of hippocampal-dependent relational memory in opposition to item-specific memory representations (e.g., the location of an item on a screen).

Differentiation of Emotional Stimuli Tested

According to Chiu et al. (2013), researchers can organize the opposing results into different categories. Hence, in "source" memory studies, researchers observe contextual/relational information through the use of operationalizing across many different procedures (i.e. perceptual features of stimuli such as color and location of an item and temporal information such as the item order within a list). However, source memory can be defined as both item detail (location on screen) and semantic, relational detail. Unfortunately, many source studies in the prior research have neither incorporated detailed distinctions between the types of relational information tested nor differentiated between memory for contextual and relational information. For instance, retrieval queries in these source studies have been limited to the recall or recognition of the source information for cued items, such as when the source is correctly remembered and attributed, and this simultaneously implies accurate memory for the content of the source itself.

In contrast to source memory studies, many experiments have been conducted in which there is not an exact relationship between the contextual or relational information and trials. For instance, commonly tested contextual or relational information tends to become trial-unique in design. As mentioned by Chiu et al. (2013), these two types of information must be distinguished in order for a true pattern in the results to be identified. When a clear distinction is made, the prior research finds emotional enhancements of memory from two specific types of source memory studies—those that involve temporal information and visual-perceptual processing. For instance, Schmidt et al. (2011) found that emotion caused an enhancement in the remembering of item order within a list, while Doerksen and Shimamura's (2001) and other researchers' (D'Argembeau & Van Der Linden, 2005; Mackay & Ahmetzanov, 2005) results showed enhancing effects of emotion on memory for the color source associated with items. Mather and Nesmith (2008), in addition, found evidence for emotional enhancement of memory for the location of information.

Furthermore, emotional memory research has also found memory impairments due to emotion which tends to involve tests for contextual information as well as for relational binding information between context and items or item-pairs. For example, following from Chiu and colleagues' (2013) argument that there is a novel pattern emerging when there is a distinction between contextual and relational memory, this prior research consistently demonstrates poor detailed memory for scenes associated with emotional stimuli (Kensinger et al., 2007), and worse recognition memory for the pairing between objects on scenes (Touryan et al., 2007; Rimmele et al., 2011) or item pairs (Mather & Knight, 2008; Pierce & Kensinger, 2011).

Relevant Theories from the Emotion Literature

To more comprehensively understand the issues caused from the absence of distinguishing among source, context, and relational information, it is worthwhile to briefly explain two views in the current emotional memory literature, as mentioned by Chiu et al. (2013). The object-based framework relates to studies showing enhancements in visual-perceptual source memory and explains that arousal enhances within-object perceptual bindings intrinsic to the items which then results in improved memory retention of such relational bindings (Mather, 2007). This object-based framework clearly explains emotional enhancements for source memory in which perceptual features such as the color or location are spatially close or combined with the emotional stimuli; hence there is a benefit of enhanced feature-binding through focused attention attracted by the emotional stimuli (Doerksen & Shimamura, 2001; D'Argembeau & Van der Linden, 2005; MacKay & Ahmetzanov, 2005; Mather & Nesmith, 2008).

In addition, the second view emphasizes a trade-off between enhancement of perceptual details for central information and an impairment of detailed remembering for peripheral stimuli. This central-peripheral trade-off theory explains impaired memory for designs that test contextual information such as scenes that serve as background for centrally presented items (Kensinger et al., 2007), or for objects that are peripheral to emotional scenes (Touryan et al., 2007). Hence, memory for central details is enhanced, albeit at the cost of peripheral information (Chiu et al., 2013).

Memory Representations Tested

As previously mentioned by Chiu et al. (2013), the absence of distinguishing between different types of source memory can be the cause of these inconsistent results. Moreover, due to the intertwined memory mechanisms being operationally defined under one definition

(contextual memory vs. relational memory), the previous two theories have been unable to produce direct predictions. So, in order to conceptualize the enhancing or impairing effects of emotional memory that generalizes across a range of studies, Chiu et al. argued for the necessity to consider the underlying memory representations likely to result from various experimental designs. In particular, a distinction between item-specific memory (memory for the characteristics of the studied item) vs. hippocampal-dependent relational memory representations (memory for the characteristics of associated items)—that supports memory for associations among several items and the larger context concerning temporal, spatial, and situational relations—needs to be considered.

Thus, source information enhanced by emotion usually involves stimuli that can be perceptually or conceptually fused in order to solely measure hippocampal-independent item-memory representations. This is the case with color or location source information that can be associated with items through a visual picture, and temporal information for multiple items that can be conceptually organized into a single, coherent sequence (Chiu et al., 2013). However, emotion that impairs accurate memory of information is supported by relational representations, such as contextual information using complex visual scenes and relational information using item pairs (Kensinger et al., 2007; Mather & Knight, 2008; Pierce & Kensinger, 2011). Therefore, because there are two categories of memory representations involved (contextual vs. relational), the current study examines the effects of emotion on item-specific memory, relational memory, and relational-binding memory, in addition to considering if and how emotion may affect these memory representations differently, through the implementation of the DRM paradigm.

Deese-Roediger-McDermott Paradigm

The Deese-Roediger-McDermott (DRM) paradigm (Stadler, Roediger, and McDermott, 1999), originally constructed by Deese (1959), is a memory testing method that attempts to replicate the experience of false memories in the laboratory. During the task, participants are asked to study lists of words that are categorized by a theme or association. All the lists contain a certain amount of words that are all associated with the keyword that is the epitome of the theme of that list (the critical lure). For instance, if the critical lure is sleep, the words presented are "bed," "alarm clock," "pillow," and so on. Following the presentation of each list the participants must recall the words that they previously studied. Although the critical lure is never presented to the participants during the study phase, participants tend to recall the word due to its strong association with the actual studied words.

The current study's solution regarding the inconsistencies in the emotional memory research was to make use of the DRM paradigm, which acted as a methodology to differentiate between contextual information (font color) and relational memory (the percentage of falsely recalled critical lures). In addition, analysis of relational-binding memory (proportion of correctly recalled critical lures paired with accurate font color) will be examined. Since the DRM paradigm has already been utilized to examine relational memory through measuring the amount of critical lures that were falsely recalled, the current study added additional information, such as font color of the words, in order to also examine item-specific memory. Furthermore, by having the critical lures in differing font colors the current study also allowed us to measure relational-binding memory.

Although incorporation of the DRM paradigm into emotional memory research has been utilized previously, it has not been utilized as a resource for differentiating between opposing memory mechanisms. The purpose of Stadler, Roediger, and McDermott's (1999) work was to

provide normative data on lists that can be used to produce false memories so future researchers can use this data as a benchmark in their experiments regarding false recall and recognition with this DRM paradigm. All thirty-six lists of words tested by Stadler and colleagues included 15 associate words of the critical lure (critical target) of that particular list. Fortunately, their results provided a vast amount of information concerning the effectiveness of the lists in creating false memory which were originally developed by Deese (1959), Roediger and McDermott (1995), and McDermott (1995). Given the validity of these word lists in eliciting the unpresented critical lure, the current study incorporated these list of words into the current, and novel, use of the DRM paradigm.

Furthermore, Corson and Verrier (2007) built on previous studies of emotion and false recall in the DRM paradigm by simultaneously examining the effects of valence and arousal on recall and recognition of non-presented critical lures. Although their results did not find support for a false memory effect for emotion, high arousal was found to be a strong indicator of false memories, with no differences in memory between positive, negative, or neutral valence. Lastly, Storebeck and Clore (2005) found results more consistent with the current study's hypotheses and methodologies while examining the affect-as-information hypothesis. The hypothesis' implications were consistent with their findings in that positively valenced stimuli improved relational processing during encoding which further enhanced false memory effects while negatively valenced stimuli increased item-specific memory accuracy and discouraged false memory effects.

The Present Study

In the current study, the study phase incorporated a version of Stadler, Roediger, and McDermott's (1999) paradigm, which already included relational memory (i.e., false recall of

critical lures), and added additional memory processes including both item-specific memory (correct recall of studied word's font color) and relational-binding memory (correct recall of critical lure's font color). There were 12 word lists (half negatively-valenced, half neutrally-valenced), all associated with a central critical lure theme (Appendix A). Although participants that are introduced to the DRM paradigm only view the words that are in the word lists, and not the critical lures, they tend to falsely recall the critical lure during a subsequent test phase due to its strong association with the other studied words in its corresponding word list.

The incorporation of the DRM paradigm here in the current study allowed for the differentiation between contextual, item-specific information (font color of studied word items), relational memory detail (false memory effect of critical lures), and relational-binding memory (font color of critical lures). By counterbalancing the word lists between two font colors, green and blue, participants' indication of correct color response for negatively-valenced vs. neutrally-valenced studied word items and critical lures were measured, which allowed for an accurate and differentiating assessment of both item-specific memory and relational-binding memory. Thus, the dependent variables tested included proportion of falsely recalled critical lures, proportion of correct color responses for old studied word items, and proportion of correct color responses for old critical lures.

Furthermore, the current study's hypotheses are as follows: (a) participants will more likely falsely recall emotional critical lures compared to neutral critical lures which is consistent with Storebeck and Clore's (2005) results that found emotionally-valenced stimuli improved relational processing during encoding and further enhanced false memory effects; (b) following from Doerksen and Shimamura's (2001) results that found emotionally-valenced words enhanced memory for font color, participants will have increased item-memory and correctly

recall font color of studied negative words more so than for studied neutral words and (c) based on Mather and Knight's (2008) results that found that memory for sound-digit pairings was negatively impacted for sounds that previously predicted negative stimuli compared to sounds that previously predicted neutral stimuli, participants will have decreased relational-binding in which they will be less likely to recall correct font color of negative critical lures as compared to neutral critical lures.

Method

Participants

Although 35 participants participated in the current study, one participant was excluded from the analyses because he recalled over 50 percent of the filler items as old, indicating a response bias. The remaining 34 participants (Male = 15, Female = 19) were between the ages of 18 and 22 (M = 18.74, SD = .86). Participants were JMU undergraduates who participated for course credit. Furthermore, all participants passed the Ishihara colorblind test.

Materials

DRM paradigm. The DRM paradigm consists of lists of semantically related words and related critical lures. The critical lures are un-presented words that closely represent the semantic category of the word lists. Each of these lists were created specifically to elicit an associated word that was not on the list (i.e., the critical lure). In addition, the word-list presentation order was consistent across all participants (Appendix B) and lists were split into two categories: negatively-valenced words and neutrally-valenced words. The current study incorporated 6 negatively-valenced word lists containing twelve words per list, all based on a semantically-related critical lure from Stadler, Roediger, and McDermott's (1999); in addition, 6 neutrally-valenced word lists were also included from the same study, with 12 words in each

list that were also based on a semantically-related critical lure. Due to the likelihood that participants may have come in contact with the SLEEP list in lecture or textbook demonstrations, it was replaced with the WINDOW list taken from Roediger and McDermott (1995). Since Stadler and colleagues previously tested the accuracy of these words lists for their capability of eliciting the non-presented critical lure and both negative and neutral emotions, the present study chose to incorporate them into the current paradigm (Appendix A).

Half of the words were presented in green font, while the other half were depicted in blue font. Color order was counterbalanced throughout word lists between two versions of participants (Version A and Version B). For example, Version A participants viewed the first word-list—CHAIR—in blue font while Version B participants viewed the same word-list—CHAIR—in the beginning of the paradigm, in green font. These word-lists were properly displayed through the use of Microsoft PowerPoint, with each slide containing one of the words on the list, in its assigned font color (Appendix C). The slides had a white background with either blue or green font for the words. Except for the differences in emotion and color, all other characteristics of the appearance of the words was homogenous, in that the size, style, type, and timing of each word was constant across conditions. Through Microsoft PowerPoint, on a standard university classroom's Dell personal computer, these 12 word lists were projected onto a 43x57 in screen size. In the PowerPoint presentation, all the words were typed in "Arial Black (Headings)" font style, with font size pt. 54. Furthermore, each word was presented to the participants for 2 s with a 500 msec delay between each word while participants were asked to read each word silently as it appeared on the screen. Furthermore, there was a 5 s delay between each word list.

Ishihara color-blind test. Six individual pictures with colored dot patterns were included in this color-blind test, with each colored dot pattern being assigned its own slide in the PowerPoint presentation (Appendix F). In each one of these patterns the multi-colored dots formed a concealed number that is only capable of being viewed by those who are not color-blind. All six of these slides, containing one pattern per slide, were presented to participants on the same computer projector screen, while participants were asked to identify the number in the pattern, and write their answer on the front of their recognition test packet. Since participants were told they would receive as much time as necessary to identify their answer for each slide, there was no specified time limit regarding the transition of these slides. Thus, all participants were asked if they had finished the current pattern before moving on to the subsequent one.

Recognition test packet. Each participant was distributed a packet in order to collect his/her results through a paper and pencil recognition test (Appendix D). Contained in this packet were careful instructions on how to proceed during the study, such as signals to stop and requests to work on a single page at a time. Below this was space for the participants to record their answers to the color-blind test, which was completed between the study phase and recognition test, which consisted of 48 studied items, 12 critical lures, and 36 filler items. Participants were given instructions as to their answer options on the recognition test. For instance, the participants were to indicate whether the presented word on the packet was *old* (i.e., previously presented) or *new* (i.e., not previously presented). Additionally, if the participants stated that a word was old, they were asked to choose the correct font color through a forced-choice option of either blue or green font color.

Procedure

The experiment consisted of a study phase, a color-blind test, and a test phase (recognition test). Once each participant was settled, the researcher welcomed the participants

and followed a script explaining the procedure and instructions of the experiment (Appendix E). Participants viewed 12 lists of words (six emotional word-lists and six neutral word-lists) with each word list containing 12 words that were presented on a PowerPoint presentation, with each word being designated its own slide (Appendix C). Each word was presented to the participant for 2 sec with a 500 msec delay between each word and a 5 s delay between each different word list. Participants were asked to read each word silently as it appeared on the screen. As mentioned above, the word lists were taken from Stadler, Roediger, and McDermott (1999), with the following non-presented critical lures: CHAIR, THIEF, CRY, WINDOW, ANGER, LIE, HELL, ALONE, NEEDLE, FRUIT, LION, and SWEET (listed in order of randomly-assigned presentation to participants).

After the presentation of word lists, there was a 5-min filler task which included a color-blind test (Appendix F). The color blind test was also administered through the same PowerPoint presentation, with each color-blind item on its own slide. After viewing each of the five images of numbers covered in multi-colored patterns (the color-blind stimuli), the participant was asked to write the correct number on the front cover page of his/her packet. Each participant was allowed to view each slide of the color-blind test until he/she was able to interpret the number and continue.

During the recognition test, participants were presented with words (some from the studied lists, critical lures, and filler items) and asked to determine if the word had previously been presented. The participants then indicated on their packet whether the presented word was an old word that was presented on the PowerPoint during the study phase or a new word that they had never seen before. If they labeled a word as old, they were asked to identify the color in which the word was presented. Participants did not have a set time to finish the recognition test

but were asked to refrain from flipping repeatedly back-and-forth between pages. Further details of the recognition test instructions can be viewed in the appendices (Appendix E). Following completion of the recognition test, participants were asked to flip over their test packets and to read over the debriefing statement (Appendix G) before leaving.

Results

A false memory effect was assessed by running a one-way repeated measures ANOVA on proportion of "old" responses by item type (studied, critical lure, and filler items). This analysis allowed for the examination of a response bias by testing the proportion of studied items (M = .67, SD = .10), critical lures (M = .71, SD = .18), and filler-items (M = .15, SD = .13) labeled as old by participants. The one-way ANOVA results (Figure 1) showed that there was a significant difference in proportion of old responses between item types (studied items, critical lures, filler items), $F(2, 33) = 260.54$, $p < .01$. In order to examine where these differences lie in the three different levels of item type, three post-hoc paired samples t-tests were conducted. To control for familywise error a Bonferroni correction was included (.05/3), which resulted in an alpha level of .017 to be adopted for all subsequent analyses. The three post-hoc test results revealed that the proportion of studied items labeled old by participants were significantly higher than the proportion of filler items labeled old by participants, $p < .01$. Similarly, the proportion of critical lures labeled old by participants were also significantly higher than the proportion of filler items labeled old by participants, $p < .001$. However, the proportion of studied items labeled old by participants and the proportion of critical lures labeled old by participants did not significantly differ, $p = .13$.

Following this, a paired-samples *t*-test was conducted to investigate relational memory processing in the proportion of falsely recalled critical lures. The repeated measures *t*-test results (Figure 2) showed that participants were more likely to correctly recall negative critical lures (M = .78, SD = .19) compared to neutral critical lures (M = .64, SD = .25), $t(33) = 3.07$, $p < .01$, d = 0.63, 95% CI [.04, .22]. Additionally, after running another paired-samples *t*-test, the current study found that there was a statistically significant effect of emotion on the proportion of correct color identifications for old negatively-valenced studied items compared to the proportion of correct color identifications for old neutrally-valenced studied items (Figure 3), $t(33) = 4.10$, $p < .001$, d = .95, 95% CI [.08, .26]. So, participants more accurately paired negatively-valenced emotional studied items with their correct color identification (M = .65, SD = .14) compared to neutrally-valenced studied items (M = .48, SD = .22). Although negative emotional studied items resulted in more accurate recall of the correct color identification compared to neutral studied items, the same effect was not observed for critical lures as evidenced in the final paired-samples *t*-test (Figure 4). There was no statistically significant difference for the proportion of correct color responses within negatively valenced critical lures (M = .56, SD = .25) and neutrally valenced critical lures (M = .59, SD = .30), $t(33) = .41$, p = .69, d = -0.098, 95% CI [-.17, .11].

Discussion

To current knowledge, this application of differentiating between item memory, relational memory, and relational-binding is a new area of research (Chiu et al., 2013). This current study attempted to follow the recommendations of Chiu and colleagues in solving the inconsistencies in emotional memory research. As mentioned previously, many researchers have found enhanced memory for emotional stimuli (Mackay & Ahmetzanov, 2005; Mather & Nesmith, 2008; Rimmele, Davachi, Petrou, Dougal, & Phelps, 2011) while others have found

conflicting results in which there was impaired memory for emotional stimuli (Mather & Knight, 2008; Mather et al., 2006; Pierce & Kensinger, 2011). Fortunately, a limited number of researchers (Christianson, Loftus, Hoffman, & Loftus, 1991; Kensinger et al. (2007); Sharot & Yonelinas, 2008) have acknowledged that emotional memory results may be conditional on the type of operationalization of the variables included in the study, in which there are multiple varying factors such as differing stimuli (picture or word) and mediums (contextual information depicted).

Thus, the current experiment's goal was to clarify these contradicting results by applying the recommendations of Chiu et al. (2013) such as specifically examining the differential roles of contextual memory (i.e., item-specific details) and relational memory (i.e., associative memory). To accomplish this, the current study modified the DRM paradigm, which is already designed to test relational memory, to include a specific item-detail (font color) as a way to differentiate these conflicting source memory mechanisms: item-specific memory and relational memory. Operational definitions of 'memory' used in prior studies have often included item-specific memory and relational memory without differentiating between the two, which means that the actual memory mechanisms being tested vary from researcher to researcher. To amend this problem, two types of memory information were differentiated in order to conceptualize the opposing results found in prior studies: contextual, item-specific information which includes stimuli such as emotional and neutral words varied by font color, and relational information which encompasses associations between semantically related content. Unfortunately, Chiu et al. acknowledged that this solution still provides results that vary from an enhancing effect of emotion on memory for individual stimuli to two differing effects of emotion on memory for simultaneous contextual and relational items, such as both

enhanced and impaired relational memory for emotional stimuli. To correct for this, the current study provided an organized categorization of which memory mechanisms were actually being represented and tested: item specific memory, relational/associative memory, relational binding.

After performing three different repeated measures *t*-tests, this study's results were mostly consistent with its hypotheses. Critical lures, which were not actually presented at the study phase, were more often identified as old as compared to studied words or filler items. Negative words were more often recognized with their accurate font color compared to neutral words and negative critical lures were more falsely recalled as old by participants compared to the neutral critical lures. Finally, mathematically, participants were less likely to correctly recognize the accurate font color of negative critical lures as compared to neutral critical lures, but this difference was not significant. Thus, these results indicate there was increased item-specific and relational memory for negative words. The hypothesis that there would be impaired relational-binding memory for negative words was not supported, although the results were trending in that direction.

These results have significant implications on the emotional memory literature. Most importantly, the current study was the first known study to follow the advice of Chiu et al., (2013) in firstly, acknowledging the conflicting results in emotional memory research and secondly, applying their recommendations through the use of the DRM paradigm, which acts as a methodology to differentiate between contextual information (font color) and relational memory (the percentage of falsely recalled critical lures). Thus, these results provide a solution to the conflicting results in the emotional memory literature, by clearing up any inconsistencies in operationally defining the correct memory mechanisms being tested.

Moreover, these results are consistent with the pattern of results that Chiu and colleagues previously predicted would occur, if a future study was to follow their suggestions. Particularly, they mention that once there is a clear distinction between contextual information and relational information, a predicted pattern of results would reveal enhanced effects of emotion on memory for item-specific memory (D'Argembeau & Van Der Linden, 2005; Doerksen & Shumamura, 2001; Schmidt et al., 2011) but impaired effects of emotion on relational memory (Kensinger et al., 2007; Touryan et al., 2007; Rimmele et al., 2011). In comparison to these results, the current findings further support this pattern found in the prior research in that, once there is differentiation between item specific memory and relational and contextual information, emotional stimuli cause enhancing effects in item-specific memory, but impairing effects for associative/relational memory. The current findings capture these differing impacts in that item-specific memory was improved with negative words, but relational memory and associative binding was harmed by negative stimuli. Hence, participants were more likely to recognize negatively-valenced word-font color pairs instead of the color of the neutral words. Since participants' memory improved for negative word-color pairs, this supports the idea that emotion can improve memory for specific characteristics of the object or stimulus. The negative emotional stimuli may have affected relational binding memory since the negative critical lures were less frequently paired with the correct color.

These results are also consistent with two relevant theories from the emotion literature explained in Chiu et al. (2013), the object-based framework and the central-peripheral trade-off theory. In the object-based framework, arousal and emotion show enhancements in visual-perceptual source memory because within-object perceptual bindings, which are intrinsic to the objects (stimuli), are improved when emotion is involved. This explains the current findings in

which there were enhancements for source memory where the perceptual feature of font color was more often recognized for (negative) emotional stimuli compared to neutral stimuli. In this framework, and in the current study, emotional stimuli attracted attention to the object and enhanced feature-binding which allowed participants to more often correctly recognize the font color of negatively valenced studied words. Furthermore, the central-peripheral trade-off theory that states the existence of a trade-off between enhancement of perceptual details for central details and an impairment of memory for peripheral details, is consistent with these results. Participants were less likely to identify the correct color pairings of falsely recalled negative, as compared to neutral, critical lures; although the difference here is negligible. This implies that there was an improvement in associative relational memory that caused the intrusion of never-before-seen critical lures to be falsely recalled as "old" words whilst a decrease in accurately identifying the relation-binding information of these critical lure's font color.

Although the current study found significant and promising results, no scientific study is without its limitations. In this experiment, possible weaknesses were few but still influential. For instance, the delivery of the emotional stimuli was quite unrealistic compared to emotional stimuli in reality. In this protocol, participants' emotions were triggered through the presentation of words; however, in realistic emotional situations, the emotion more directly affects the individual. Although these were standardized negative and neutral word lists that were tested to elicit negative and neutral emotional responses, future studies might benefit from including more realistic representations of emotion. Moreover, future research should follow the current study's protocol in implementing the recommendations of Chiu et al. (2013), while simultaneously testing out different modes of source memory.

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Figure 1. Proportion of studied, critical lure, and filler items labeled "old" by participants. One way repeated measures ANOVA was conducted to measure for response bias, that was not found.

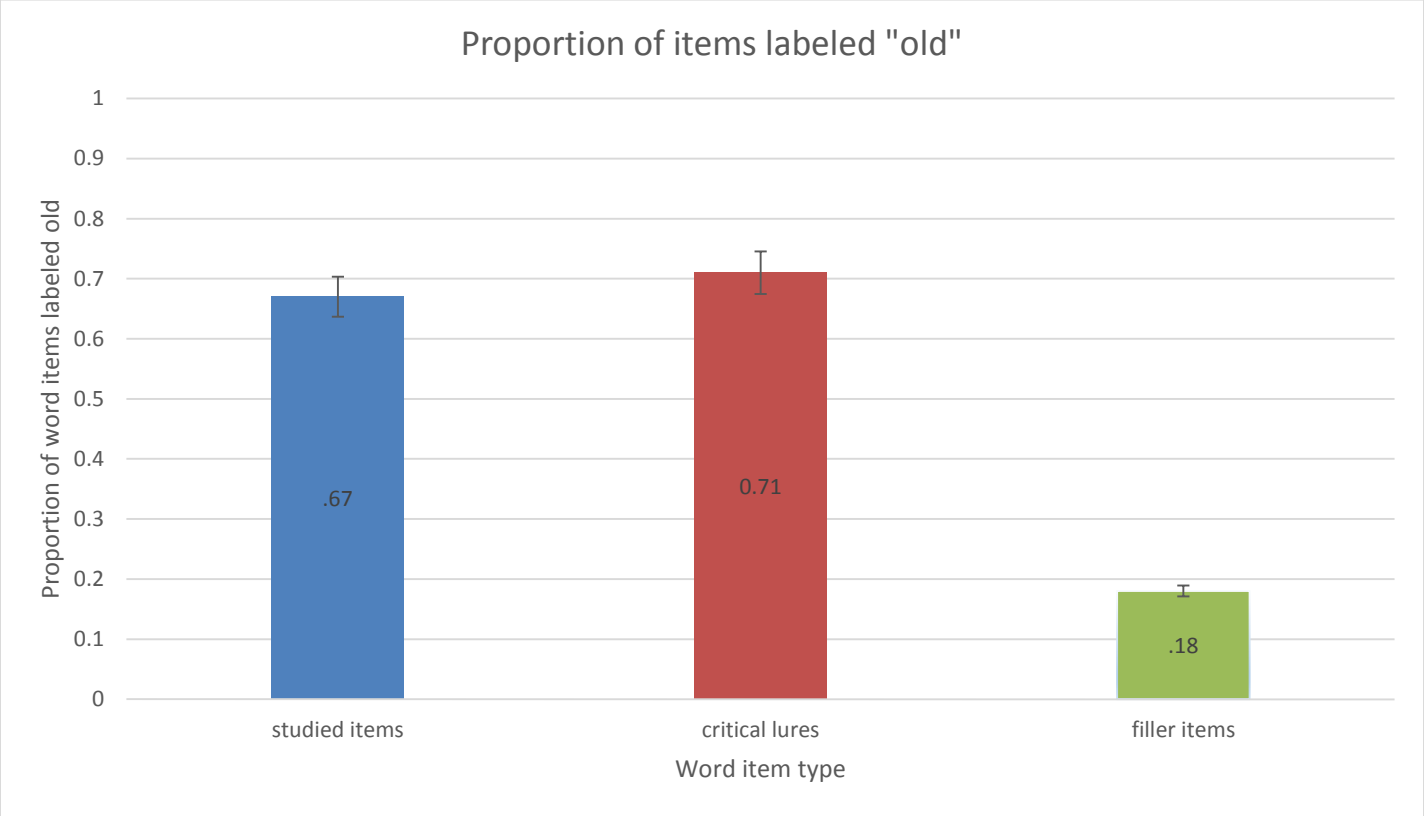


Figure 2. Proportion of critical lures falsely recalled as "old" by participants. These results show support for emotional stimuli improving relational memory.

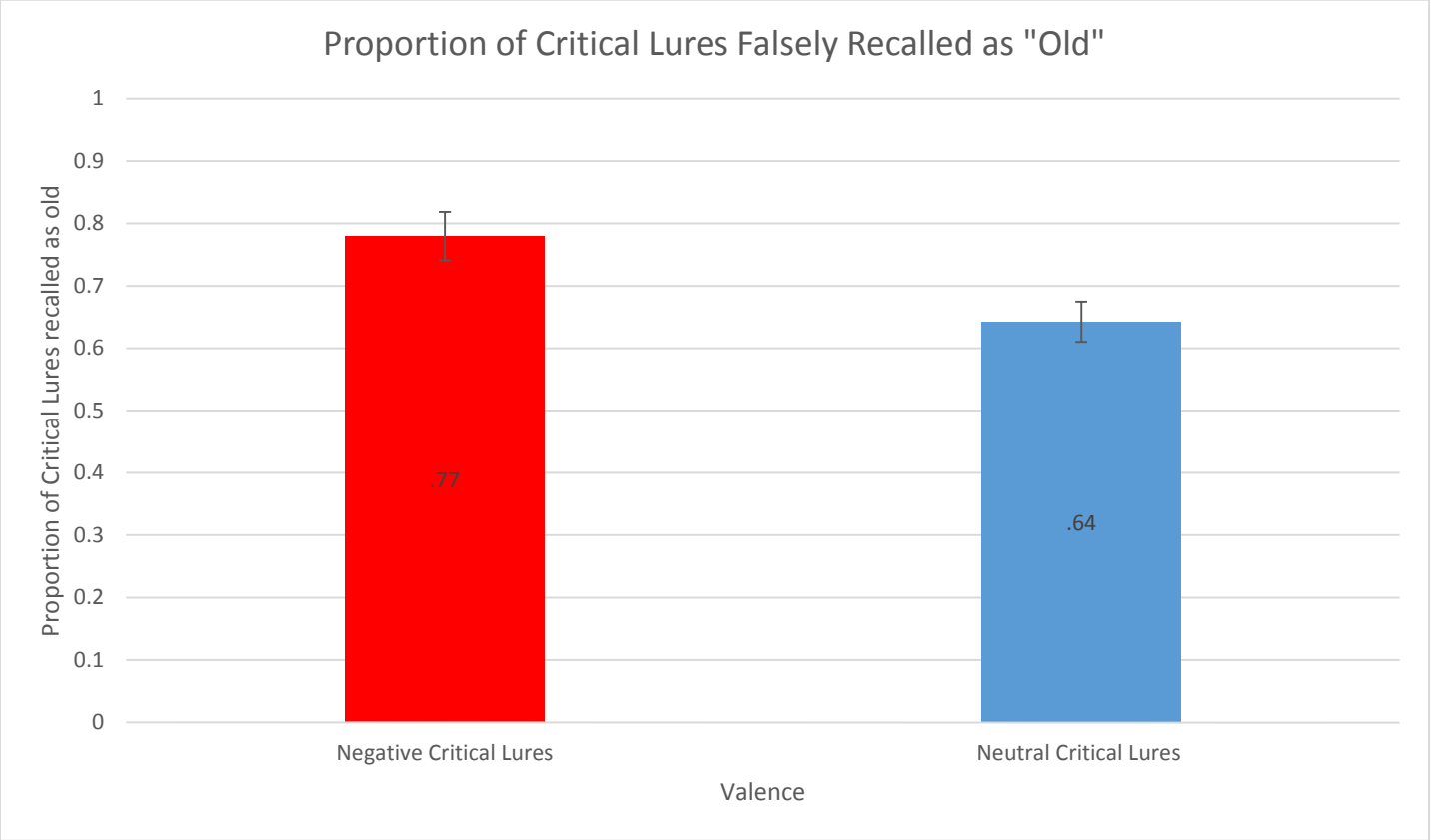


Figure 3. Proportion of correct color identifications for old "Emotional" Studied items compared to Proportion of correct color identifications for old "Non-Emotional" studied items. These results show support for emotional stimuli enhancing item-specific memory.

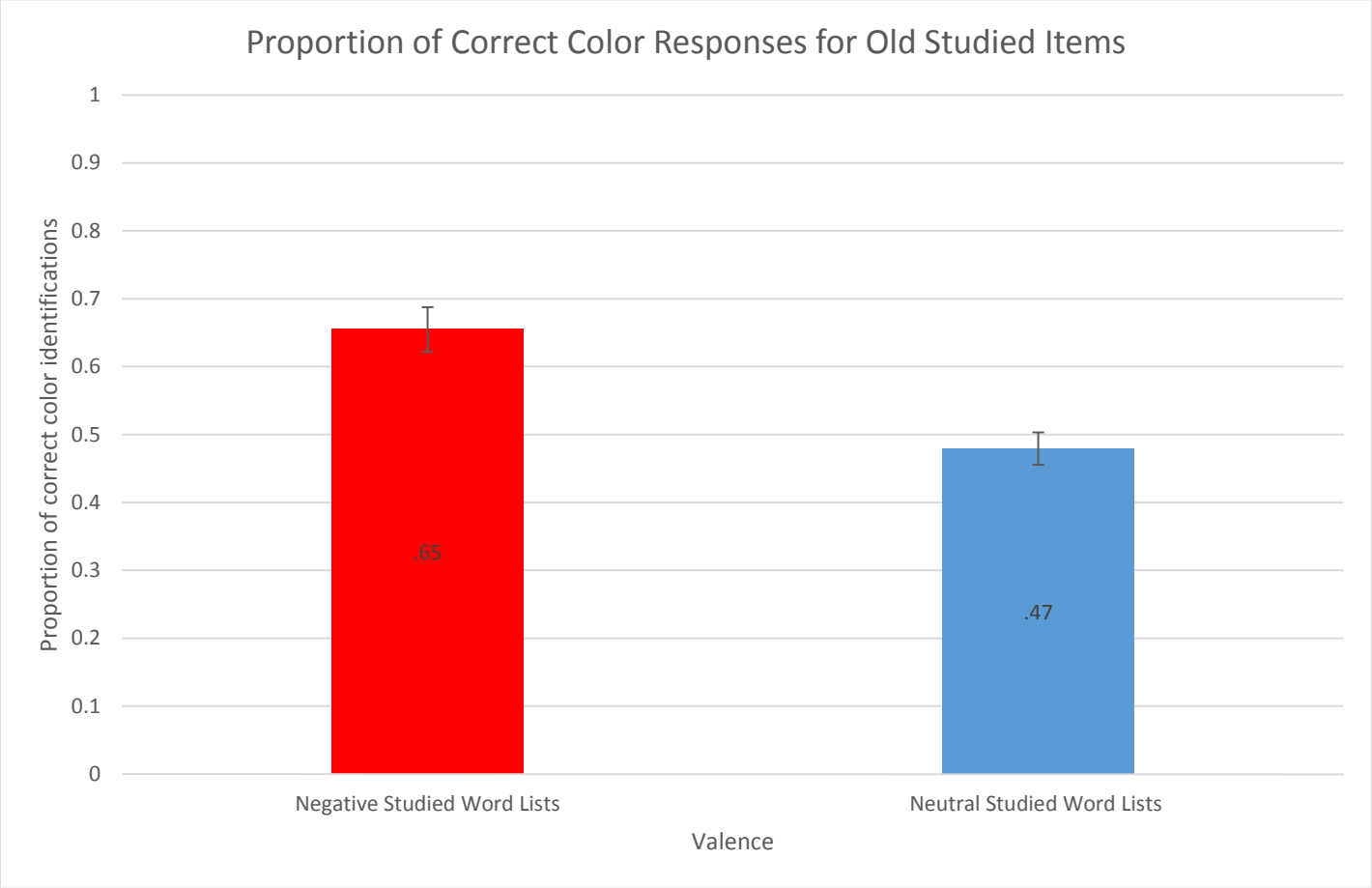
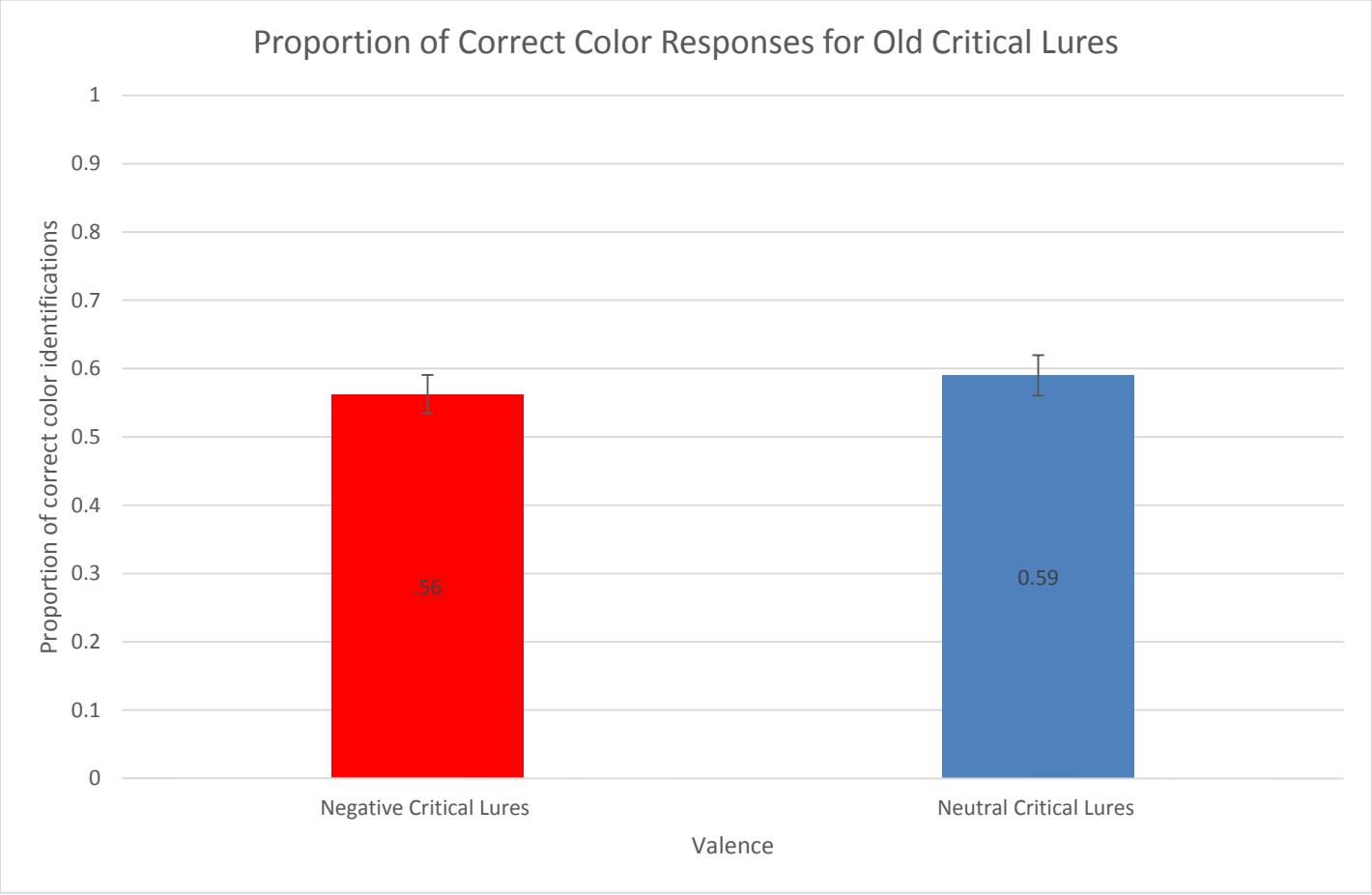


Figure 4. Proportion of correct color identifications for old "Emotional" critical lures compared to proportion of correct color identifications for old "Non-Emotional" critical lures.



Appendix A. Stadler, Roediger, and McDermott's (1999) constructed neutral and negative word-lists.

Negative-emotional lists

CRY	LIE	ANGER	HELL	THIEF	ALONE
Tears	Fib	Mad	Devil	Steal	Single
Sad	Cheat	Fear	Satan	Robber	Isolated
Tissue	Truth	Hate	Evil	Crook	Abandoned
Sorrow	False	Rage	Damned	Burglar	Solitary
Eyes	Mislead	Temper	Sin	Money	Apart
Weep	Trick	Fury	Lucifer	Cop	Lonesome
Sob	Fake	Wrath	Demon	Bad	Separate
Bawl	Sneak	Fight	Heaven	Rob	Quiet
Frown	Pretend	Hatred	Soul	Jail	Detached
Unhappy	Deceive	Mean	Judgment	Gun	Solo
Upset	Secret	Calm	Beast	Bank	Self
Down	Honest	Enrage	Fire	Bandit	Unaided

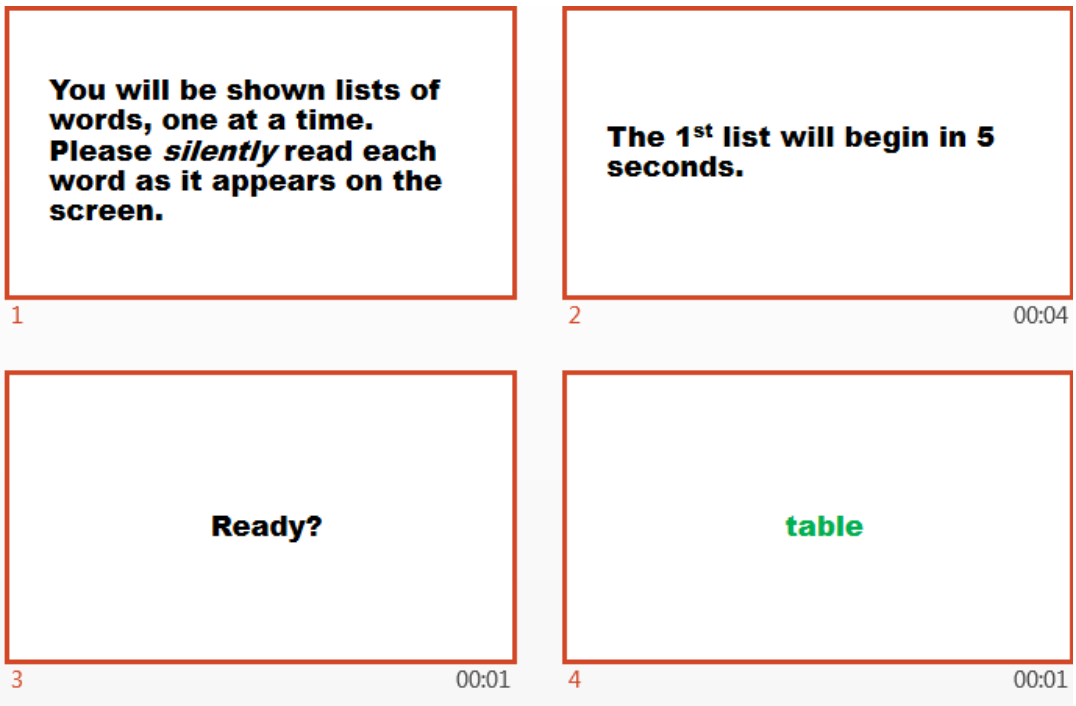
Neutral Lists

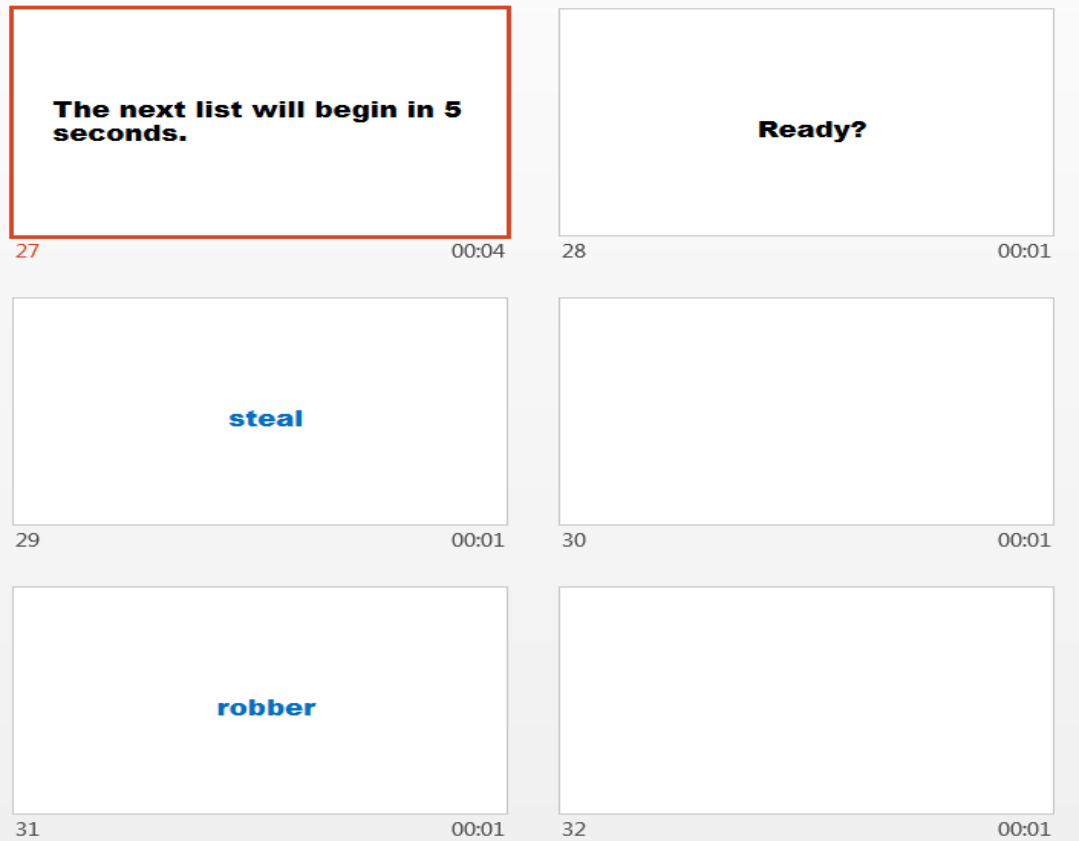
FRUIT	CHAIR	SWEET	LION	NEEDLE	WINDOW
Apple	Table	Sour	Tiger	Thread	Door
Vegetable	Sit	Candy	Circus	Pin	Glass
Orange	Leg	Sugar	Jungle	Eye	Pane
Pear	Seat	Bitter	Tamer	Sewing	Shade
Banana	Couch	Good	Den	Sharp	Ledge
Berry	Desk	Taste	Cub	Point	Sill
Cherry	Sofa	Tooth	Africa	Prick	House
Basket	Cushion	Nice	Mane	Thimble	Open
Juice	Sitting	Honey	Cage	Haystack	Curtain
Salad	Stool	Chocolate	Feline	Thorn	Frame
Bowl	Bench	Pie	Hunt	Cloth	View
Cocktail	Rocking	Heart	Pride	Knitting	Breeze

Appendix B. Word-list order in the DRM paradigm (font color will be counterbalanced between word-lists across Versions A and B).

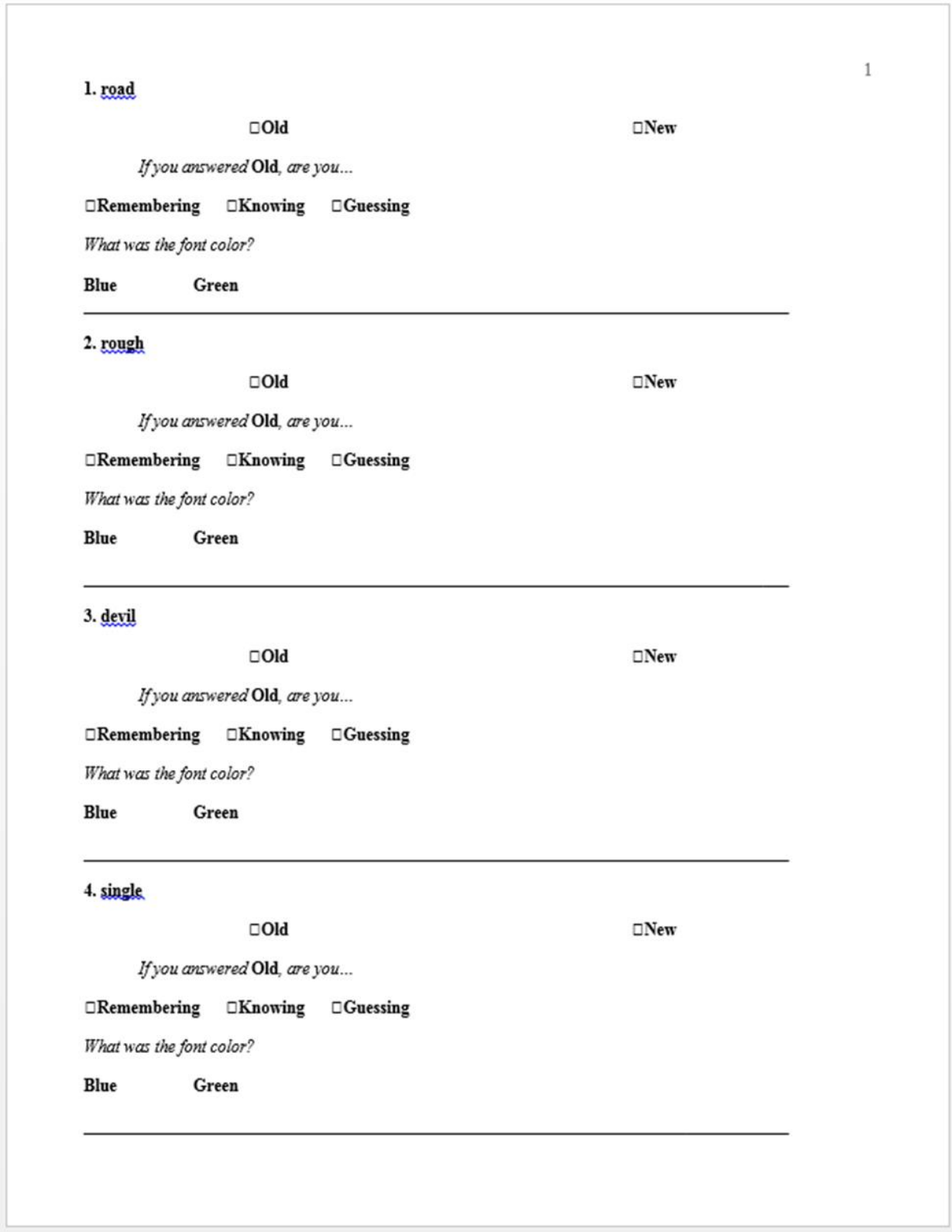
CHAIR
THIEF
CRY
WINDOW
ANGER
LIE
HELL
ALONE
NEEDLE
FRUIT
LION
SWEET

Appendix C. Examples of PowerPoint presentation slides (DRM Paradigm) that were administered to participants. This slide is the beginning of Version B.





Appendix D. A page from the recognition test administered to participants after viewing DRM paradigm.



1

1. road

□Old **□New**

If you answered **Old**, *are you...*

□Remembering **□Knowing** **□Guessing**

What was the font color?

Blue **Green**

---

2. rough

□Old **□New**

If you answered **Old**, *are you...*

□Remembering **□Knowing** **□Guessing**

What was the font color?

Blue **Green**

---

3. devil

□Old **□New**

If you answered **Old**, *are you...*

□Remembering **□Knowing** **□Guessing**

What was the font color?

Blue **Green**

---

4. single

□Old **□New**

If you answered **Old**, *are you...*

□Remembering **□Knowing** **□Guessing**

What was the font color?

Blue **Green**

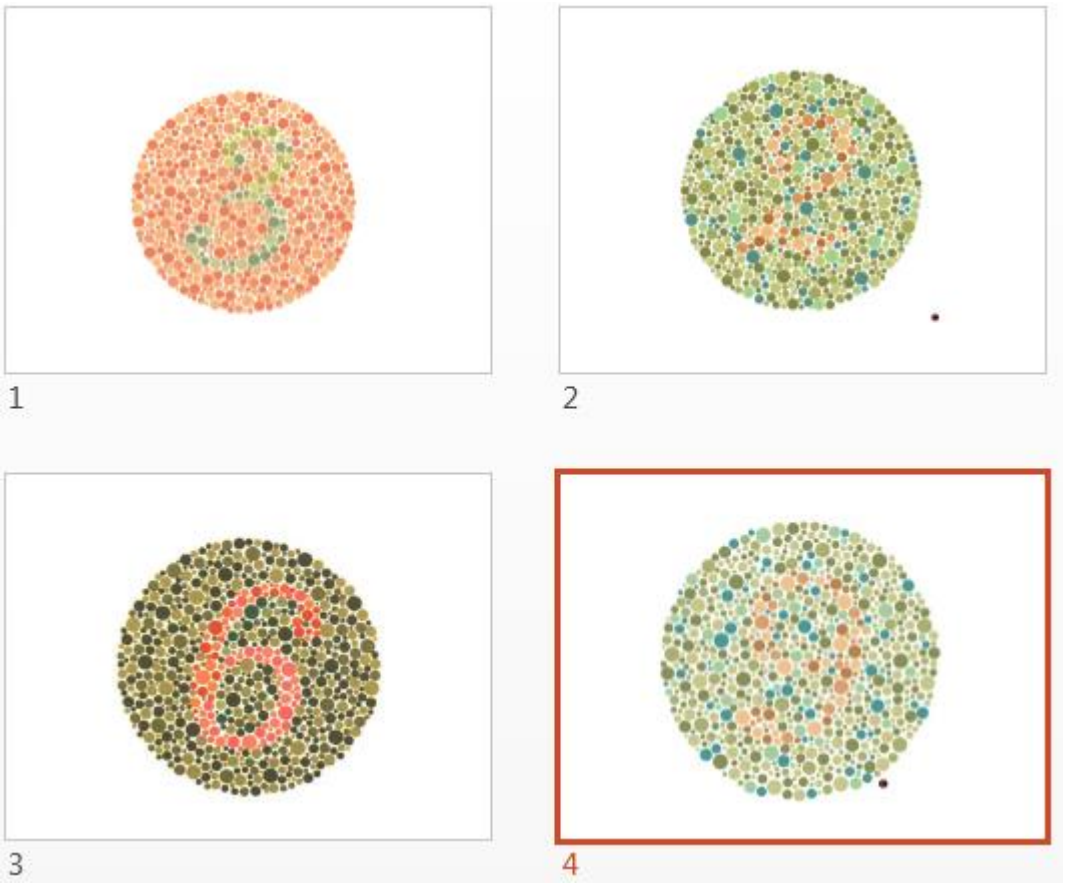
Appendix E. Researcher instructions read to participants at the beginning of the experiment.

You are going to view a PowerPoint presentation. In this presentation you will see several lists of words. Please **PAY CLOSE ATTENTION** and read **EACH WORD** silently to yourself. It may seem like a long time but only takes about 5 minutes so please try your best to concentrate. The words will appear on the screen automatically. When you are finished, please wait for further instructions.

1. **Color Blind Test:** For this next part I would like you to write down the number that you see in each circle
2. **Recognition Test:** On the following recognition test, you will find some words that you have studied, and some words that you have not studied. You are to make one decision about these words—remember or know.

    Remembering: You have a conscious recollection of what happened or what was experienced at the time the word was presented. You can recall details like: how the word looked, what words preceded or followed, what you were doing or thinking, or what was going on in the room when the word was presented.
    Knowing: You recognize the word as being part of the list but cannot vividly recollect anything about its actual occurrence or what happened at the time it was presented. The word does not evoke any specific conscious recollection but you are certain you recognize the word.
    Please use these definitions as you make your decisions. Do you have any questions? Please answer each word in the correct order, do not flip back and forth through the packet. It is double sided. Also, please answer quickly, as I want to see your gut reactions. This shouldn't take you more than 10 minutes.

Appendix F. Color-Blind Test



Appendix G. Sample of Debriefing Statement administered to participants after the recognition test.

Debriefing Statement: The memory experiment you just completed was a test of the effects of emotional stimuli on memory. In this experiment, we were examining: the effects of emotional words on source memory. In addition, we were testing two theories regarding the effects of emotion on memory: enhanced memory for item-specific details, versus enhanced memory for relational information. These two different memory contexts were represented in the study phase. Item-specific memory was defined as percent of correctly recalled words and their associated color. Relational information deals with memory of details that are associated with the content. For example, many words that were presented to you during the test phase were not in the study phase, however, they were associated with other words in a thematic words list. For example, studied words might have been “devil”, “Satan”, and “Lucifer”, and the non-presented associated word might have been “hell.” If you falsely recalled the word “hell” this would be representative of relational details. Thank you for your participation and if you have any further questions, please contact the researcher or Dr. Fogler after the experiment is complete.