THE ROLE OF ENCODING SPECIFICITY IN INCIDENTAL LEARNING: IMPLICATIONS FOR EXPLICIT AND IMPLICIT FALSE MEMORIES

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Abstract

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This research investigated false memories via spreading activation and the influence of encoding specificity on explicit and implicit memory tests in incidental learning situations. It was hypothesized that congruent conditions would have higher rates of both false memories for associated items as well as more accurate memories for presented items. It was also expected that this effect would be larger among those in implicit memory conditions compared to explicit conditions. The participants (n=175) were presented with Deese-Roediger-McDermott semantically associated word lists via a Stroop task, in which they were not told to remember the words presented, but to instead identify the font color of the word. The font color of the presented word lists was either the same (congruent) between the learning and memory tests, or it was different (incongruent). With respect to false memory, a significant interaction for memory condition and font color was found, such that those in the implicit condition had more false memories for non-presented words when in the incongruent font color condition, and those in the explicit condition had more false memories when in the congruent font color condition. Regarding memory accuracy, both those in the implicit and explicit conditions had more accurate memories when in the congruent font color condition. Overall, the explicit condition had more false memories and more accurate memories than those in the implicit condition. This research shows that significant differences exist among implicit and explicit false memories regarding the effects of encoding specificity in incidental learning situations.

Table of Contents

List of Figures

List of Tables

List of Appendices

The Role of Encoding Specificity in Incidental Learning: Implications for Explicit and Implicit False Memories

Most people are familiar with the fact that our memories are far from perfect. However, most people are less familiar with how perceptual features and the differences among the kinds long-term memory affect our memories. Our memory is prone to errors, deviations, and distortions that are often referred to as false memories (Fairfield, Colangelo, Mammarella, Di Domenico, & Cornoldi, 2017). A false memory is a memory that is different from what actually happened. The broad aim of this study is to understand the cognitive mechanisms that contribute to false memories. Some aspects that affect false memories are perceptual features of information (Kellogg, 2001; Vaidya, Gabrieli, Verfaellie, Fleischman, & Askari, 1998).

Perceptual features of memories are facets within a memory that are obtained through the sensory system (e.g. visual information, auditory information, olfactory information, etc.). Perceptual features can aid one's memory, as memory is facilitated when the learning and retrieval conditions overlap, a phenomenon known as encoding specificity. It is often the case that perceptual features are learned without one's awareness or intent, or incidentally. However, the role of perceptual features and encoding specificity are unknown for false memories. In addition, it is possible that the different types of memory systems (i.e. explicit and implicit) are affected differently by encoding specificity for false memories (Ko, Duda, Hussey, Mason, & Ally, 2014; McKone & Murphy, 2000; Sbicigo, Janczura, & de Salles, 2017). This research will address the central question: Does encoding specificity affect explicit and implicit false memories differently? The current study addresses this question by presenting information that varies in perceptual features that people are not instructed to learn (e.g. incidental learning). The goal is to identify whether these perceptual features affect the creation of false memories differently when the perceptual features match or differ (e.g. encoding specificity) between learning and retrieval for explicit and implicit memory conditions. A review of the literature discusses false memory research, types of long-term memory, incidental learning, and encoding specificity.

False Memory Research

Research is necessary in order to further understand false memories and how they affect our lives. Researchers study false memories in a multitude of different ways, such as examining how the framing of questions can affect retrieval and reconstruction of memories (Loftus & Palmer, 1974), how exposure to information can lead to the creation of an entire event that never happened (Coan, 1997; Loftus & Pickrell, 1995), and how mental representations of concepts can cause false memories (e.g. Brewer & Treyens, 1981; Roediger & McDermott, 1995). For the purposes of this paper, the creation of false memories via the relationship of mental representations will be highlighted.

The semantic organization of mental representations via the semantic network may lead to the creation of false memories. For example, Brewer and Treyens (1981) found that participants falsely remembered items as being present in an office room, when they were in fact not present at all. The researchers attributed these results to the schemata, or the mental representations of concepts as a way of organizing information. Schematas can lead to false memories due to the activation of semantic associates.

Semantic associates are items that are related in meaning and are connected in the semantic network within our brains. An office room and other items that were present in an office room (i.e. a desk, writing utensils, an office chair, etc.) are semantically associated to the items that were falsely remembered (i.e. books). This is a real world example of false memories brought on by the activation of semantic associates.

Semantic associates, due to the linkage between information within the semantic network, often lead to intrusion errors, as the associated items (i.e. a desk, writing utensils, an office chair, etc.) lead to the spontaneous intrusion of other semantically related ideas (i.e. books). This intrusion is known as an intrusion error, which is one way that false memories can occur. An important next step in false memory research is to look more deeply into the underlying cognitive mechanisms behind intrusion errors to understand more about this type of false memory. There are multiple methodologies to address this research, however, perhaps the best and most widely used method is the Deese-Roediger-McDermott (DRM) list learning paradigm (Roediger & McDermott, 1995).

Deese-Roediger-McDermott paradigm. The DRM paradigm is widely used due to its relevance regarding false memories caused by intrusion errors. In most studies that employ the DRM paradigm, researchers present a specially designed list of words to participants that they are later tested upon. The words in this list are special because they are semantically related to each other. For example, researchers present the words “glass”, “pane”, “shade”, and “ledge” and other words related to the concept “window” to participants. However, in most cases, the word that links all the items on the list (the critical word or critical lure), in this case “window”, is not presented. Yet, studies consistently observe that participants spontaneously and falsely recall and remember the critical word, “window”, from the list (McDermott, 1997; Roediger & McDermott, 1995; Smith & Randall, 2011). In other words, the DRM word lists consistently produce false memories of the critical words in the form of intrusion errors.

Theories of False Memories

There are two main theories explaining how false memories occur in the DRM paradigm: the fuzzy-trace theory and the activation-monitoring theory. The fuzzy-trace theory (FTT) accounts for false memories by gist traces (Brainerd & Reyna, 2002). Gist traces are basic essence memories while verbatim memories are exact memories (Brainerd & Reyna, 2002). For example, if someone were to misplace their keys, a gist trace would be thinking that the keys are on the key hook just because that is where they usually are and there is a faint memory of them being there. The problem with gist traces is that they can be wrong and can lead to error, as they are reliant on faint memory traces. Let’s say that the keys were in fact on the kitchen counter and there is a precise and exact memory of them being there. This would be a verbatim memory because the memory accurately represents exactly what happened. If a verbatim trace is present, it is thought to be prioritized over present gist traces. According to FTT, gist traces occur when verbatim traces are not strong enough, resulting in an increase in false memories (Brainerd & Reyna, 2002).

Although FTT can account for some aspects of false memory creation, there is much more theoretical and experimental support for an alternative theory, the activation-monitoring theory. The basis of the activation-monitoring theory are two cognitive processes: spreading activation and monitoring (Roediger, Watson, McDermott, & Gallo, 2001). The activation-monitoring theory is highlighted for the purpose of this study.

Spreading activation. Spreading activation is a process that may contribute to the creation of false memories within the activation-monitoring theory. Spreading activation refers to the process within the semantic network in which the activation of a collection of cells associated with a specific concept, like “pane”, spreads to other collections of cells associated with related concepts, like “shade” and “window”. The semantic network is the network of neurons in the human brain that connect various ideas and concepts related via meaning, or semantically. When one semantic associate is consciously activated within the network, a subsequent subthreshold activation of all other associates (i.e. spreading activation) occurs subconsciously (Anderson & Pirolli, 1984; Ratcliff & McKoon, 1988).

The spreading activation in the semantic network works analogously to neural firing. In order for a neuron to fire, it is required that an action potential meets a threshold level of activation, referred to as the threshold of excitation. When discussing the semantic network, the threshold refers to the specific point that is required for information to reach consciousness; subconscious information is below the threshold level. For both neural firing and the consciousness threshold in the semantic network there is an all-or-none law. The threshold must be met; otherwise the neural firing or conscious activation does not occur. Exposure to a DRM list results in the conscious activation of words that were presented, such as “glass”, “pane”, “shade”, and “ledge”.

Subthreshold activation of “window” occurs as well and increases with each presentation of each semantically related item. When enough subthreshold activation adds up to breach the threshold, the activation of the non-presented word, “window”, reaches consciousness. Once the activation of “window” reaches consciousness, there is an experience of the word, even though it was internally generated by an accumulation of activation, rather than being presented in the outside world and perceived through the senses. This makes it likely to experience a false memory of the word. In other words, the critical word intrudes into consciousness. Thus, this type of false memory would be an intrusion error.

Another example of spreading activation leading to the intrusion of falsely remembered information via incidental learning is the office room experiment (Brewer & Treyens, 1981). In this study, the instructions given to participants were to wait for the experiment to begin while sitting in an office room. The researchers then moved participants to the so-called “experimental room” and gave them a surprise memory test in which they were instructed to recall all the items in the office room they had just left. The learning of the contents in the office room was not intentional in this study; researchers did not provide information conveying that there would be a memory test based on objects present in the room. Therefore, participants were not actively trying to memorize the items that were present. Most participants reported remembering “books” as items present in the office room when in reality, there were actually no books present in the room at all. The recollection of “books” is in fact a false memory created by an intrusion error. When participants were sitting in the office room, they noticed conventional objects that are associated with offices, such as a desk, writing utensils, and an office chair. Seeing these items initially in the office room activated other related concepts, such as books. These items were then reactivated during the test on the room items, when participants were asked to recall the contents of the office room. The repeated activation of the neurons within the network that represent each of these concepts was strong enough to breach the conscious activation threshold of semantically associated concepts that were not actually present in the room (i.e. books).

This process of spreading activation within the semantic network occurs among cell assemblies and phase sequences. Cell assemblies are groups of neurons that represent an individual concept, such as a desk or books. Various cell assemblies that are related to each other in meaning (e.g. desk and books) are grouped together in what is referred to as a phase sequence (e.g. in this case “office stuff”). Thus, a phase sequence is a collection of cell assemblies within the semantic network, indicating that a phase sequence is a collection of semantically related concepts. The neural connectivity between cell assemblies (individual concepts like desk and books) is strengthened each time a cell assembly concept (desk) is presented together with another cell assembly concept (books) (Danker & Anderson, 2010). This strengthened connection facilitates subsequent communication between cell assemblies (i.e. spreading activation). Ordinarily this process is helpful in one’s ability to think efficiently, however, this same process may govern the creation of false memories of semantically related concepts.

The process of spreading activation within the semantic network occurs among cell assemblies of a phase sequence and contribute to the creation of false memories. The

DRM paradigm takes advantage of how information is organized in the brain (semantically) to induce false memories. The words from a given DRM list are semantically related concepts. Thus, the words on the list represent cell assemblies that are part of a larger phase sequence. Due to the fact that related concepts are linked together, when a given concept (cell assembly) is activated, all related concepts in the phase sequence are sent small amounts of activation (subthreshold) via spreading activation. With the accumulation of this activation (e.g. from words like “glass”, “pane”, “shade”, and “ledge”), the likelihood of a highly related item that was never presented (i.e. “window”) is likely to reach the necessary threshold level for one to consciously experience the word by having it intrude on one’s thoughts. Spreading activation has been used to account for the findings of numerous false memory studies stemming from intrusion errors (Castel, McCabe, Roediger, & Heitman, 2007; Coane, McBride, Raulerson, & Jordan, 2007). However, there is more to false memories, such as monitoring processes that occur during encoding and retrieval.

Monitoring. Monitoring is another process that likely contributes to the creation of false memories via intrusion errors within the activation-monitoring theory. Monitoring refers to the strategic and consciously controlled supervision of one’s memory (McDermott & Watson, 2001; Roediger et al., 2001). Monitoring is any memory process of which the purpose is to determine the origins of activation (Gallo, 2010). This means that during encoding or retrieval, if there is a conscious attempt to determine the source of the information, monitoring processes are likely occurring.

Monitoring during encoding only occurs in intentional learning situations because one cannot consciously determine the source of information if they are not intentionally learning the information. For example, when the participants were sitting in the office room in Brewer and Treyens (1981) they were not intentionally memorizing the items that were present in the room. Therefore, it was not possible for them to monitor the encoding of this information, because monitoring requires conscious supervision.

However, monitoring during retrieval can occur when information was learned incidentally. The participants in Brewer and Treyens (1981) likely monitored the retrieval of the incidentally learned items in the office room, whether successfully or not. Monitoring processes must occur to determine whether things are actually present in the environment or are present in the mind due to external cues when monitoring during encoding (McDermott & Watson, 2001). For example, monitoring during encoding may occur in an intentional learning situation in which a participant is studying a DRM semantically associated word list. Such a situation may involve an active supervision of whether activation in the brain for a word (e.g. “window) is due to the presence of that word in the study material or due to internally generated activation. Monitoring processes must occur to determine whether activation is due to an event that actually occurred or due to the presentation of associated items when monitoring during retrieval (McDermott & Watson, 2001). For example, monitoring during retrieval may occur in a situation in which a participant is tested on their explicit memory via a recognition test of a semantically related word list that they studied previously. Such a situation may involve an active supervision of whether or not the memory of the word they are seeing is being activated in their brain because they previously studied it or because it is semantically related to other words they studied (i.e. an intrusion error). Monitoring during retrieval only occurs when one is using their explicit memory system because implicit memories are subconscious and therefore cannot be consciously monitored.

False memories can result from errors in monitoring processes, or failing to accurately monitor the source of the activation that lead to a memory (Gallo & Roediger, 2002). Monitoring has been found to increase correct recollections while decreasing the frequency of false memories (Gallo, 2010). Research has found that manipulating the monitoring process influences the accuracy of one's memory and the frequency of false memories. For example, altering the way information is stored in one's long term memory and repeated testing can affect the monitoring process.

Presenting DRM lists in a blocked fashion rather than in random order increased both correct and false memories (McDermott, 1996). In other words, presenting blocked lists improved memory for the lists but also increased the rate of false memories. Information in a blocked fashion means that things are presented in groups, in this case, semantically associated lists being presented sequentially. Blocked lists alter the monitoring processes during encoding because it changes the way the information is organized and stored in long-term memory. When semantically related word lists are presented in a blocked fashion, they are stored together not only semantically, but temporally. Therefore, researchers can facilitate monitoring, which can result in more memories. The reason that both correct and false memories increased with this manipulation is that the information became more strongly connected due to the multiple associations (i.e. temporal and semantic). However, it also strengthens the connections to other related information that was not actually present (Castel et al., 2007). These results show that monitoring processes at encoding influence false memories. Altering the way that information is stored within the long-term memory, such as blocked list presentation, increases both accurate and false memories.

The monitoring process can be influenced by repeated testing. Repeated testing resulted in more accurate memories and less false memories (McDermott, 1996). Repeated testing alters the monitoring processes during retrieval due to more frequent retrieval of the information after being stored in long-term memory. Repeated retrieval can make it easier to access information because the retrieval pathway within the cortex becomes stronger each time it is accessed. This strengthening of the retrieval pathway results in faster retrieval of the information (i.e. neurons that fire together, wire together). These results show that monitoring processes at retrieval influence false memories because repeated testing resulted in more accurate memories and less false memories.

Types of Long-term Memory

False memories via intrusion errors can affect different long-term memory systems. The composition of long-term memory consists of two main types of memories: explicit and implicit. Explicit memories are those that we can consciously retrieve and of which we are aware. Implicit memories are a bit more enigmatic in that we are not cognizant of them and are unaware of when they are affecting our behavior. An overview of these memory systems is presented below.

Explicit memory. Explicit memories require conscious thought. Explicit memory and declarative memory are synonymous because you can consciously declare the contents of explicit memories. For example, the questions "what did you do for your birthday" or "what is your name" result in explicit memories because the answers are things of which most people are consciously aware. Within explicit memories, there are various subtypes of memory, two of which being episodic and semantic memories. Episodic memories are explicit memories in which people are able to recall contextual information (e.g. sensory, temporal, and spatial information) associated with the memory of the event. So in this case, the answer to "what did you do for your birthday" would contain contextual information such as, who was present, what you did, the type of cake (and perhaps the taste of it), and perhaps the auditory experience of the happy birthday song.

Semantic memories, on the other hand, are explicit memories in which one is able to recall information, such as facts and other knowledge that is not associated with contextual information (e.g. sensory, temporal, and spatial information) of the memory of this event. So in this case, the answer to "what is your name" is not associated with you remembering the actual circumstance of when you learned your name, you simply are able to state your name.

Contextual information is not necessary in order to know, for example, that the word "window" and the word "pane" are associated. However, a connection forms between semantic memories and episodic memories if one can remember learning about the words "window" and "pane" during a specific occasion. For example, let's say someone is doing a task in which they are to learn word lists, whether purposefully or incidentally, of semantically related items, such as “window” and “pane”. Meanwhile, there is specific contextual information occurring at the same time, such as the smell of lavender. The information that is being learned (i.e. “window” and “pane”) is becoming associated with the contextual information (i.e. the smell of lavender) within the cortex. Knowledge becomes stronger and more resilient with more connections within the semantic network when such associations occur between the two types of explicit memories.

Implicit memory. Implicit memories, on the other hand, are memories that are subconscious. This type of memory is non-declarative, meaning declaration of the contents of implicit memories cannot happen. This type of memory can change behavior and thoughts unknowingly. Like explicit memory, there are different types of implicit memory: procedural memory, learning through conditioning, and priming. The implicit memory type of relevance to the current project is priming and is detailed below.

Priming. Priming is a subconscious change in behavior that is the result of a presented stimulus influencing response patterns to either the same stimulus or a related stimulus that is presented after. For example, let’s say someone is participating in an experiment on a computer in which the purpose is to indicate the colors of pictures of objects. Before the person is presented with a picture of a banana, the computer screen turns yellow for a short amount of time. Afterwards, the person may be able to indicate that the banana is yellow more quickly than if the computer screen did not turn yellow first. This would be an example of successful priming. Priming occurs without conscious reliving of an experience, making it a product of implicit memory rather than explicit memory (Ko et al., 2014). Reliable priming occurs in various cognitive tasks through implicit false memories using the DRM paradigm (Garner & Howe, 2014; Howe, Garner, Dewhurst, & Ball, 2010; Howe, Threadgold, Norbury, Garner, & Ball, 2013; McDermott, 1997; Sherman & Jordan, 2011). In these cases, the experiment consisted of presentation of semantically associated words (e.g. “pane”, “shade”, “ledge”) and the critical word (e.g. “window”) was the answer to an implicit memory task. Various word association tasks have been used (Howe, Garner, Charlesworth, & Knott, 2011; Sherman & Jordan, 2011) in order to test the priming effects of false memories.

Priming occurs subconsciously and unbeknownst to the person. The person undergoing the priming does not control the differences in behavior that may result. There are many kinds of priming, two of which being conceptual priming and perceptual priming. Either conceptual or perceptual implicit memory tests can measure these kinds of priming. Conceptual implicit memory tests are tasks that require subconscious relationships to be made about concepts, such as a word association task. The instructions for this task are to come up with as many associated words as possible to a word, such as “pane”. If participants can make associations to the critical word, “window”, conceptual priming has taken place. Perceptual implicit memory tests feature perceptual cues, such as a word fragment task or a word stem completion task. The instructions for this task are to complete the stem/fragment with the first word that comes to mind, such as the stem “win----” or the fragment “w--do-w”. If one completes these word tasks predictively, perceptual priming has taken place.

The present experiment will examine perceptual priming and word stem completion tasks. Word stem completion tasks are an accurate measure of perceptual implicit memory because participants are taking in perceptual information before making their response and are encouraged to quickly produce the first word they think of, without consideration of a specific correct answer (Sbicigo et al., 2017). Therefore, a word stem completion task is a valid measure of perceptual implicit memories and, in turn, can accurately tell us whether successful perceptual priming has occurred.

Explicit false memory research. Use of the DRM paradigm is common in explicit false memory research (McDermott, 1997; Roediger & McDermott, 1995; Rummer, Shweppe, & Martin, 2009). There are differences between explicit and implicit false memories, such as a modality effect in which information presented auditorily reduces implicit false memories, but not explicit false memories (McKone & Murphy, 2000). This modality effect simply means that information presented visually rather than auditorily increases susceptibility to implicit false memories. These findings imply that implicit memory retrieval might rely more on perceptual information, such as visual stimuli, compared to explicit memory retrieval. Additionally, with repeated presentation of a word list, more explicit false memories occur. However, implicit false memories do not show this effect (McKone & Murphy, 2000). Explicit memories are dependent on the conscious retrieval of information from long-term memory. Therefore, it seems apparent that additional presentation of information leads to a more concrete basis for a memory in long-term memory.

Explicit memory is tested via recall or recognition tasks and can be used to measure explicit false memories (Dodd & MacLeod, 2004; McDermott, 1997; Roediger & McDermott, 1995). In a recall task, after having been presented with a list of words, participants are then asked to report all the words they remember being presented. In false memory studies, when participants report the critical word (e.g. “window”) it is a false memory. In a recognition test, after having been presented with a list of words, participants are presented with words and are asked to identify whether they are “old”, meaning they have been seen previously, or “new”, meaning that they have not seen that word yet during the experiment. In false memory studies, when participants identify a critical word (e.g. “window”) as “old”, it is a false memory. The current study employs a recognition memory test to examine explicit false memories.

Implicit false memory research. False implicit memories of critical words occur when semantically associated word lists are presented (Lovden & Johansson, 2003; McDermott, 1997). These findings imply that the activation that spreads to the critical word can occur subconsciously. The use of Korsakoff’s amnesia patients is common in implicit memory research because although their explicit memories are affected by their disease, their implicit memory system often remains normally functioning (Bechara, Tranel, Damasio, Adolphs, Rockland, & Damasio, 1995; Evrard, Colombel, Gilet, & Corson, 2016; Vaidya et al., 1998). This difference is due to the fact that amnesia is often the result of damage to the hippocampus. The hippocampus is involved only in explicit memories. Korsakoff’s patients have a smaller than average amount of explicit false memories of critical words when presented with DRM word lists when compared to people with normally functioning memory systems (Van Damme & d'Ydewalle, 2009). Implicit false memories do not show this effect. In addition to a damaged explicit memory system, part of this memory disorder is impaired relational encoding, or the ability to form new associations among concepts (Van Damme & d'Ydewalle, 2009). Thus, activation of the critical word would not occur in the explicit memory system, but activation would occur within the implicit memory system. Therefore, implicit false memories are susceptible to all kinds of relationships (e.g. perceptual and conceptual) among concepts within amnesiac patients as well as those with normally functioning memory systems.

Presentation of DRM word lists is useful in studying conceptual and perceptual implicit false memories (McDermott, 1997). Explicit, conceptual implicit, and perceptual implicit false memories all occur with the presentation of DRM lists. In McDermott (1997), tests for these memories included a word association task, a word fragment task, and a word stem completion task. The presentation of semantic associates was enough to produce not only explicit false memories, but implicit false memories as well. However, the role of perceptual details that may influence explicit and implicit false memories is unknown. This study employs a word stem completion task to examine perceptual implicit false memories.

Incidental Learning in Explicit and Implicit False Memory Tests

Incidental learning is learning that occurs without the intention of learning. Incidental learning and priming may seem similar, but are different aspects of a similar concept. While priming is a change in behavior as a result of exposure to an item, incidental learning is a process by which one's implicit memory can be primed. Incidental learning can be what happens before priming, but this is not always the case. For example, let us recall the participant in the experiment identifying the colors of pictures of objects. When the computer screen turned yellow for a short amount of time, the participant was not intending to learn anything about the yellow computer screen. However, when her response time was faster in identifying the color of a banana, the yellow computer screen primed her response. Therefore, although unintended, the participant did in fact learn about the yellow computer screen. Incidental learning occurred, which led to successful priming. When learning is intentional versus incidental, there are improvements in explicit memory but there are no effects on implicit memory (Neill, Beck, Bottalico, & Molloy, 1990). Information about an upcoming memory task resulted in the improvement of only explicit memories (Neill et al., 1990). This means that correct memories increase with knowledge of an upcoming explicit memory test, and false memories should decrease, but that such knowledge does not affect implicit memory. Therefore, in incidental learning studies that measure explicit memories, it is best to not inform participants about the following memory test.

Incidental learning in explicit false memory tests. While intrusion errors within the explicit and implicit memory systems can occur when participants purposively learn the DRM lists, the intrusion errors that result in false memories do not require intentional memorization of DRM lists. Presenting the word lists as part of a stroop task is a way to accomplish incidental learning (Dodd & MacLeod, 2004). A stroop task (Stroop, 1935) is most often a task where words are presented in different font colors. The challenge in this experiment stems from the task, as participants are asked to ignore the word (e.g. "red") while identifying the font color (e.g. blue). This task is one that most people find difficult because processing the color of the text requires people to override the automatic process of reading the word, as evidenced by the errors and time it takes to complete the task. The current study utilizes one of the many variations of the stroop task.

Dodd and MacLeod (2004) utilized a stroop task in their false memory experiment. Their study included the presentation of DRM word lists in one of four colors (e.g. red, blue, yellow, and green). In this task participants were told to only read the color of the font in which the word lists were presented and to ignore the actual words. The participants were to indicate the color of the font by pressing a corresponding key on a keyboard (e.g. red=1, blue=2, yellow=3, green=4). Due to the research utilizing stroop tasks (Stroop, 1935), an assumption is that the participants still read and processed the words although the instructions explicitly stated to refrain from reading the word. The learning in Dodd & MacLeod (2004) is incidental because the participants processed the information without the goal of memorizing or even reading the word items. Yet, despite the lack of intention of learning the words, with a surprise explicit memory test, participants in the incidental learning condition recognized the critical words (e.g. "window") as an old word, despite the fact that the word was actually new (Dodd & MacLeod, 2004).

Participants in another incidental learning study were unable to say that they remembered the words or explicitly knew that they were presented, yet the test revealed that they still had an alarming amount of false memories (Seamon, Luo, & Gallo, 1998).

With the presentation of DRM word lists for extremely short periods of time (either 2, 20, or 250 ms), participants were not confident about the presentation of certain words during the short-lived study phase. Despite the lack of confidence, participants still showed an astounding amount of false memories. The subconscious activation within the semantic network occurs without evidence that any learning happened at all. Both of these incidental learning studies show that incidental learning of DRM lists is enough to result in explicit false memories. This suggests that the creation of false memories via spreading activation of semantically related associates can occur subconsciously, but lead to conscious recollections of false events.

Incidental learning in implicit false memory tests. Incidental learning can also affect implicit memory. There is little literature that delves into the connection between these two phenomena. However, the research that has been done shows that incidental learning can indeed prime implicit memory (Tajika, Neumann, Hamajima, & Iwahara, 2005). For example, participants were presented with semantically associated word lists and one of three types of instructions: control instructions, imagery instructions, or imagery plus writing instructions. The imagery instructions consisted of imagining a visual representation of other related words, while the imagery plus writing instructions added having to write down the related words they imagined. This is an example of incidental learning because the goal of the task was not to memorize or learn the presented word lists. Implicit memory tests revealed that for all three groups there was an equivalent amount of priming for critical non-presented words and actually presented words. This effect was not seen in the explicit memory test, meaning that participants in this group had more recognition for actually presented words than critical non-presented words. It is not only suggested that incidental learning has great effects on implicit memory, but also that perhaps the activation of implicit false memories is more susceptible to perceptual aspects (e.g. visual information) compared to explicit memory.

Encoding Specificity

Encoding specificity is the idea that memories are context-dependent, meaning that if contextual conditions during learning and test are similar, there is a facilitation of retrieval of long-term memories, more so than if conditions are different (Tulving, 1974; Tulving & Thompson, 1973). Encoding specificity effects are not completely dependent on completely identical conditions across learning and test. For example, scuba divers were asked to learn information while either on dry land or underwater (Godden & Baddeley, 1975). An assumption is that the scuba divers were cold when underwater. Upon being tested, the divers who were underwater experienced facilitated retrieval of the information with the simultaneous presentation of cold-related thoughts. A connection was made between the information that was learned underwater and thoughts about being cold. This means the encoding and storage of information happens together so there is a facilitation of retrieval when contextual information is present.

Encoding specificity effects are due to the storage of information in the semantic network. Upon learning information, not only is there storage of the intended information, but there is also storage of aspects of the learning context along with the intended information. Arguably, there are connections among all the stored intentionally learned information and the incidentally associated contextual information in our long-term memory via neural connections within the semantic network. Associations form between categories for information with other cell assemblies associated with the category, such as associations forming between cold-related thoughts and the intended information for scuba divers learning underwater (Godden & Baddeley, 1975).

Encoding specificity effects can occur in a wide variety of conditions such as through perceptual features (Vaidya et al., 1998), environmental factors (Grant, Bredahl, Clay, Ferrie, Groves, McDorman, & Dark, 1998) and modality of presentation (Kellogg, 2001). One perceptual feature that can have an effect on encoding specificity if information is presented in a visual text format is font color (Vaidya et al. 1998). What this means is that people should attempt to have congruent conditions across learning (encoding) and retrieval in order to improve their memory for learned information.

For example, if one intends to learn information about horses and the presentation of the information is in a pink font, the same pink font should be used when tested on the same information about horses. This congruence should facilitate retrieval of the information more so than if the font color was different, such as green. If aspects such as these are congruent, memory is better. This is due to the fact that the encoding and storage of information is synchronized, there is a facilitation of retrieval when contextual information is present. After learning the information about horses, it is stored in the semantic network where there may be information about donkeys and mules or other semantically related concepts. Additionally and important to this study is that a link also exists between the horse information and the pink font. The connection that is made between the perceptual information and learned information leads to an increase in spreading activation throughout the brain. This facilitates retrieval because there are multiple pathways to the target information. Reliance on pure memorization of the information is not necessary when the connections to the information are rich with contextual details, making them more easily accessible. Upon test on the horse information, if the testing font is pink then the connection between the horse information and pink font is more likely to be activated and thus, strong enough to facilitate retrieval. If the font had been green during the test, the connection would not have been activated in the semantic network and the information about horses would be more difficult to retrieve.

The activation process within the activation-monitoring theory and encoding specificity go hand-in-hand. If concepts are related in multiple ways, the activation of multiple cell assemblies and potentially multiple phase sequences strengthens the connection between them. If related both semantically and physically, the cell assemblies representing word associates (e.g. “pane”, “shade”, “ledge”) become part of an even larger phase sequence, which now includes those physical characteristics and the brain regions associated with them (Danker & Anderson, 2010). The physical characteristics in this circumstance can be any sensory information. The strengthening of the connection and the increased spreading that occurs with the inclusion of physical similarities among concepts results in an increased subconscious activation of non-presented semantic associates (e.g. “window”). Although some research exists, there is not sufficient research on how encoding specificity affects explicit and implicit false memories.

Explicit encoding specificity. Encoding specificity is an important variable in explicit memory (Ray & Reingold, 2003). People are more confident in their explicit memories when representations in their mind are more substantial (Craik, Rose, & Gopie, 2015). A way of making neural representations of concepts stronger is to provide more similarities and relationships among them, such as perceptual characteristics. Concepts with weak neural representations are not sufficient to support explicit memory, but can be enough to support implicit memory (Craik et al., 2015). Theories such as this support the idea that implicit memories are more susceptible to perceptual specificity. Therefore, if learning and testing occur in congruent conditions, stronger implicit memories should result, more so than if conditions are incongruent. However, these strong effects are not present in explicit memories.

Implicit encoding specificity. Implicit memories are more sensitive to perceptual information, such as color, than conceptual information (Engelkamp, Zimmer, & Vega 2001; Tajika et al., 2005). Similarly, color produces a priming effect in perceptual implicit memory (Hupbach, Melzer, & Hardt, 2006). Color is a reliable method of showing the effects of encoding specificity within implicit memories. More research on encoding specificity must be done in order to determine the effects of perceptual characteristics on perceptual implicit false memories. Perhaps implicit memory is more susceptible to false memories than explicit memory when perceptual specificity is involved.

Current Study

The issue of false memories is one that has far reaching implications. False memories occur when learning is incidental (Dodd & MacLeod, 2004; Seamon et al., 1998) and can occur in explicit (Dodd & MacLeod, 2004) and implicit (McDermott, 1997; Neill et al., 1990) tests. It is also known that encoding specificity helps people remember when the test condition matches the learning condition (Tulving, 1974; Tulving & Thompson, 1973) and that more spreading activation leads to more false memories (Castel et al., 2007). However, there is little knowledge regarding the implication for false memories as a result of incidental learning concerning the encoding specificity effect. Arguably, encoding specificity should not affect false memories because the "learning" never happened. Yet, the activation-monitoring theory may argue that indeed false memories may be rich with details associated with the learning of similar items and that these memories are very dependent on the monitoring processes involved in encoding and retrieval.

The current study addresses the role of encoding specificity in incidental learning and its implications for explicit and implicit false memories. In this study, participants incidentally learned the contents of DRM word lists via a stroop task. Like Dodd and MacLeod's study (2004), participants were asked to identify the font color of a word while ignoring the word itself. However, in contrast to Dodd and MacLeod, who presented a given word list in all possible colors, the present study links a given word list to a specific and single font color (e.g. presentation of words in the "window" list, such as “glass”, “pane”, “shade”, and “ledge” were in blue), counterbalanced between subjects.

To examine the role of encoding specificity on explicit and implicit memory, one of two different tests were presented to participants, an explicit test or a perceptual implicit test. Like Dodd and MacLeod’s study (2004), an explicit recognition test was be used. In Dodd and MacLeod (2004), the test items were presented in a neutral font color that did not match the original font color from the color identification phase. The current study adds an encoding specificity component, where for some word lists, presentation of the items was in a neutral (incongruent) font color or in a font color that matches (congruent) the font color from the encoding phase. In the congruent font color condition, it was expected that there will be a formation of associations among the font color (i.e. blue) and the critical word (i.e. “window”) within the semantic network. Given the nature of encoding specificity, expectations were that during the recognition test, participants would have more correct memories for words like “glass”, “pane”, “shade”, and “ledge” when presentation is in a congruent font color (i.e. blue) compared to the neutral (incongruent) font color. It was also expected that with the presentation of the critical word (i.e. “window”) in the recognition test, participants would be more likely to have a false memory when it too was presented in the font color (i.e. blue) that matches its semantically associated words, as compared to when the test items were presented in a neutral (incongruent) font color. Thus, it was expected that when the test conditions matched the learning conditions there would be higher accuracy for presented words (e.g.

“glass”, “pane”, “shade”, “ledge”, etc.) and more false memories for the critical word (e.g. “window”) compared to incongruent font color conditions.

This study sought to address the differences between explicit and implicit false memories, and thus also employed an implicit memory component. Due to past research (Engelkamp et al., 2001; Hupbach et al., 2006) suggesting that implicit memories are more susceptible to neurological spreading in regards to perceptual information, expectations were that false memories would occur at higher rates in the implicit test compared to the explicit test. In the implicit test, after incidentally learning the DRM words via the stroop task, participants completed a word stem completion task (see McDermott, 1997). The word stems were either in a congruent font color as presented in the color identification phase, or were presented in an incongruent font color. Like the explicit test, expectations were that those in the implicit test would have higher accuracy for presented words and more false memories when the conditions were congruent from color identification to test phase compared to incongruent font color conditions. However, there was a difference in expectations between the explicit and implicit conditions: significantly more false memories and accurate memories in the implicit memory condition.

The past literature on false memories has not addressed whether incidental or subconscious learning of DRM lists would result in both explicit and implicit false memories, or a difference between the two. Additionally, considering the findings that color encoding is a perceptual factor that influences implicit memories more than explicit memories, congruent font color between color identification and test should yield more implicit false memories than explicit false memories.

Hypotheses/Predictions

Hypothesis 1a. I expected an interaction effect between test type and font color in false memory frequency. I hypothesized that when participants are tested on their implicit memory, they would have more false memories than those being tested on their explicit memory if the font color was congruent between color identification and test. I expected that if participants were tested in an implicit test, congruent font color would facilitate spreading activation and thus, would lead to more false memories compared to those tested in an explicit test. This prediction is in line with findings suggesting that implicit memories are more reliant on perceptual information than explicit memories (Engelkamp et al., 2001; Hupbach et al., 2006; Tajika et al., 2005; Vaidya et al., 1998) and that more spreading activation can also lead to more memory errors (Castel et al., 2007; Gallo, 2010; Roediger et al., 2001).

Hypothesis 1b. I expected a main effect of test type in false memory frequency. In this incidental learning situation, I hypothesized that if participants were tested in an implicit test, they would have a higher rate of false memories compared to those tested in an explicit test. This prediction is in line with findings that incidental learning leads to more implicit memories than explicit memories (Neill et al., 1990, Tajika et al., 2005) and that more spreading activation can also lead to more memory errors (Castel et al., 2007; Gallo, 2010; Roediger et al., 2001).

Hypothesis 1c. I expected a main effect of font color and false memories. I hypothesized that when participants were in congruent font color conditions, they would have a higher frequency of false memories compared to when they were in incongruent font color conditions. This prediction is in line with the theory of encoding specificity, such that congruent conditions at encoding and retrieval facilitates memory (Godden & Baddeley, 1975; Grant et al., 1998; Tulving, 1974; Tulving & Thompson, 1973) and that more spreading activation can also lead to more memory errors (Castel et al., 2007; Gallo, 2010; Roediger et al., 2001).

Hypothesis 2a. I expected an interaction effect between test type and font color in memory accuracy. I hypothesized that when participants were tested on their implicit memory, they would have greater memory accuracy than those being tested on their explicit memory if the font color was congruent between color identification and test. I expected that if participants were tested in an implicit test, congruent font color would facilitate spreading activation and thus, would lead to more accurate memories compared to those tested in an explicit test. This prediction is in line with findings suggesting that implicit memories are more reliant on perceptual information than explicit memories (Engelkamp et al., 2001; Hupbach et al., 2006; Tajika et al., 2005; Vaidya et al., 1998).

Hypothesis 2b. I expected a main effect of test type in accuracy. In this incidental learning situation, I hypothesized that when participants were tested in an implicit test, they would have greater memory accuracy compared to those tested in an explicit test. This prediction is in line with findings that incidental learning leads to less accurate explicit memories, but does not affect the accuracy of implicit memories (Neill et al., 1990).

Hypothesis 2c. I expected a main effect of font color and memory accuracy. I hypothesized that when participants were in congruent font color conditions, they would have greater memory accuracy compared to when they were in incongruent font color conditions. This prediction is in line with the theory of encoding specificity, such that congruent conditions at encoding and retrieval facilitates memory (Godden & Baddeley, 1975; Grant et al., 1998; Tulving, 1974; Tulving & Thompson, 1973).

Method

Participants

The participants in this experiment were 175 Humboldt State University students. The sample size was determined through an a priori power analysis, using a power level of 0.8 and an effect size of 0.5. Participants consisted of 131 females and their ages ranged from 18-46 years old, (*M* = 20.94, *SD* = 4.35), all of whom reported having normal color vision. The participants received course credit or extra credit in their psychology courses for participating in this experiment.

Materials

Four DRM lists that are known to elicit high levels of false memories (from Stadler, Roediger, & McDermott, 1999) composed of 15-items each were used and are presented in Appendix A. The memory tests included words from the four DRM lists and included 8 filler word items: anger, chair, flag, shoe, king, needle, rubber, spider. The filler words were taken from other unrelated DRM lists (Stadler et al., 1999).

Design

This study was an experimental 2 (memory test) x 2 (font color) mixed-subjects design. The variable memory test was a between-subjects factor with two levels: explicit test (recognition test) and perceptual implicit test (word stem completion task). In the recognition test, instructions to participants were to identify whether a given word was originally presented during the color identification phase (e.g. old) or whether it is a word that was not previously presented (e.g. new). The implicit memory test was a word stem completion task. Participants were presented with word stems composed of three initial letters and were asked to complete the word stems quickly with the first word that came to mind.

The variable font color was a within-subjects factor with two levels: congruent and incongruent. The font colors used in this experiment were red, blue, green, and yellow. In the congruent condition, the word lists were presented in the same font color in the color identification phase and at test. In the incongruent condition, the font color at test was presented in a neutral font (i.e. white) that was never presented in the color identification phase.

The dependent measures in this experiment were recognition memory accuracy (percent correct) of list items in the explicit test, word stem accuracy (percent reliable priming) of list items in the implicit test, false explicit memory rate (percent of false memories to the critical word in the recognition test), false implicit memory rate (percent critical words used to complete word stems), and reaction time.

Procedure

Participants engaged in the experiment individually in a lab suite. Both verbal and text instructions were provided for all participants on how to make color judgements in the color identification task.

Presentation of the word lists was via a stroop task for all participants, following Dodd and MacLeod (2004). Presentation of the word lists was in one of the four colors (red, blue, green, or yellow). Each word list had a color associated with it. In order to ensure familiarization with the procedure, participants engaged in 72 practice trials (as per Dodd & MacLeod's study, 2004). In the practice trials the participants were presented with a string of asterisks (e.g. *****). Presentation of the asterisks was in a single color per each trial. Each of the four specific font colors corresponded to four specific keys on the keyboard (e.g. red=1, blue=2, green=3, yellow=4). Participants were instructed to indicate the color of the asterisks with the corresponding key. The color identification phase of the experiment was self-paced and upon each response, participants were presented with a row of white asterisks to indicate that the next string of asterisks would appear in 500 ms (as per Dodd & MacLeod, 2004).

After the practice, participants were asked to engage in the same color identification task, but instead identifying the font color of asterisks, participants were asked to identify the font color of a text word. Participants were asked to ignore the word, as if it were asterisks, and continue to identify the color of the font by pressing the same keys from the practice trials. In total, there was 48 color identification trials (the 12 strongest associates from each DRM list). Each of the four DRM word lists was presented in a single font color, counterbalanced between participants (i.e. “window” list in all four colors, “sleep” list in all four colors, etc, resulting in 16 total conditions). Common practice when utilizing DRM lists is to present all of the words from a given list in a specific order, from strongest to weakest associated word, such that each word is presented one after another until the word list is completed. However, due to the nature of the current study and the fact that each list corresponds to a specific color, it was necessary to randomize the color of the words, to avoid patterns among the colors in the color identification task. The current study maintains the ordering of the words from strongest to weakest associate, but does so at the cost of presenting an entire list completely before presenting the content from other lists. Thus for the current experiment, the four lists were presented in an intermixed fashion, but were linked in strength of word association. This means that the first four words that were presented were the strongest associates from the four semantically related word lists and were randomized in presentation, the second four words that were presented were the second strongest associates and randomized in presentation, etc.

Participants were not forewarned of the second part of the experiment, the memory test. Participants were randomly assigned into one of the two different memory test conditions (explicit or implicit). The presented 36 items in both test conditions are as follows: the 4 critical words that correspond with each DRM list, 16 standard related items from each list that were presented during the color identification phase (words 2, 4, 8, and 9 from each list), 8 weakly related items that were not presented during the color identification phase (words 13 and 14 from each list), and the 8 unrelated unpresented filler words. There is a slight variation in the words chosen when compared to Dodd & MacLeod's (2004) memory test. This was to ensure that no words with the same first three letters were presented during word stem completion task.

For both memory tests, the words or word stems were in either a congruent font color as presented in the color identification phases or a different neutral (incongruent) color (i.e. white font color). Presentation of two of the DRM lists and the two associated critical lures were in congruent colors as presented in the color identification phase and presentation of the rest were in incongruent (white) colors. The congruent and incongruent lists varied between participants. Presentation of the eight filler words was in one of the five colors (red, blue, green, yellow, or white) at random. All test words were presented in a randomized order.

Explicit test. Participants in the explicit test condition were tested using a recognition task. Participants were presented with the words in a randomized order (as per Dodd & MacLeod, 2004) on the center of their computer screen. The recognition was self-paced, meaning presentation of the words continued until participants indicated whether the word was new or old. Instructions were to respond "/" for old and "z" for new. Old indicated that the participant did remember the presentation of that word during the stroop task. New indicated that the participant did not remember presentation of that word during the stroop task.

Implicit test. Participants in the implicit test engaged in a word stem completion task. Participants were presented with three letter initial stems on a computer screen for 12 seconds and were instructed to quickly complete the stem with the first word that came to mind, following McDermott's procedure for testing perceptual implicit false memories (1997). Participants typed their responses using a keyboard.

Results

Data Cleaning and Scoring

The data was collected via E-Prime and processed with R. Outliers for reaction time for both the color identification task and the recognition test were eliminated from the analysis and were determined as lying two standard deviations away from the mean. Using this criteria, 103 cases were omitted from the analysis. Additionally, three cases were identified as not responding to any of the word-stems and were therefore omitted from the analysis.

The implicit test data required scoring due to the open-ended nature of the task. Research assistants scored participants' responses to the word-stem completion tasks as either accurate ("1") or inaccurate ("0"). Two research assistants did all of the scoring, with each assistant scoring half of the responses. Whenever they were unsure, they came to a consensus before making a decision regarding a score. Both conservative and liberal scoring methods were used. In order for a response to be considered accurate conservatively, it had to be exactly the same word as the word that was expected by researchers (e.g. participants responded to the stem "sha-" with the word "shade"). In order for a response to be considered accurate liberally, it had to be the exact word that was expected, but misspelled, or had to contain the same base as the word (e.g. participant responded to the stem “sha-” with the word “shading” or “shades”). The same procedure took place for false memories (e.g. participants responded to the stem “sle-” with the word “sleep” to receive a conservative “1” or “sleeping” to receive a liberal “1”). A reference sheet for the research assistants was created and can be seen in Appendix B.

Responses to the explicit memory test are considered accurate memories if they are correct in identifying old words as “old” or new words as “new”. Responses to the implicit memory test are considered accurate memories if they are correct in responding to a word stem with the expected word that was presented during the color identification task (i.e. responding to “led-” with the word “ledge”). Responses to the explicit memory test are considered false memories if they respond to the critical lure word as “old”, when it is in fact new. Responses to the implicit memory test are considered false memories if they respond to the stem of the critical lure word with the critical lure word (i.e. responding to “win-” with “window”).

Analyses

The data was found to meet the assumptions of the binomial distribution. All data were analyzed using R (R Development Core Team, 2013) and the R packages lme4 (Bates, Maechler, Bolker, Walker, & Christensen, 2009), languageR (Baayen, 2013; cf. Baayen, 2008), and MuMIn (Barton, 2018). Mixed effects models were used for analysis, accounting for variance between individual subjects and words by deeming them as random effects (Baayen, 2008; Clark, 1973). Predictor (dependent) and fixed (independent) variables are specified per each analysis. For each analysis ANOVAs were used to compare each of the models to null models, in order to obtain a X^2 value.

Analyses for Each Hypothesis

Hypothesis 1a. It was expected that those tested on their implicit memory would have more false memories if they were in the congruent font color condition, as compared to the explicit memory condition. For this model, the dependent variable was false memory frequency, while the fixed effects were memory test condition (explicit or implicit) and font color (congruent or incongruent) and were allowed to interact. The main effect results stemming from this analysis are reported under the results headings "Hypothesis 1b and 1c".

Results from the mixed effects analysis show that when scored conservatively (see Table 1), there was a significant difference in false memory frequency (b* = 1.33, *SE* = 0.39, z = 3.42, p < .001, Marginal R^2 = .11), between those in implicit memory condition (*M* = 0.43, *SD* = 0.50) and those in the explicit memory condition (*M* = 0.83, *SD* = 0.37) when the font color was congruent. The model was found to be a good fit when compared to the null model ($X^2(1) = 11.99$, p < .001). The liberal scoring (see Table 2) showed the same relationship (b* = 1.29, *SE* = 0.40, z = 3.28, p = .001, Marginal R^2 = .08) between those in implicit memory condition (*M* = 0.49, *SD* = 0.50) and those in the explicit memory condition (*M* = 0.83, *SD* = 0.37) when the font color was congruent, as the results from conservative and liberal scoring were not significantly different (t = -1.01, p = .31) for false memory frequency. The model was found to be a good fit when compared to the null model ($X^2(1) = 10.99$, p < .001) Figure 1 shows that the interaction is not in the direction that was predicted, such that those in the implicit memory condition had more false memories when also in the incongruent font color condition compared to the congruent condition, while for the explicit memory condition more false memories were found in the congruent font condition compared to the incongruent font condition.

Table 1

Hypothesis 1. Conservatively scored model of false memory frequency

	Estimate	Std. Error	z-value	*p*
(Intercept)	1.83	0.47	3.86	<.001***
Condition Implicit	-2.07	0.30	-6.84	<.001***
Font Color Incongruent	-1.00	0.29	-3.40	<.001***
Condition Implicit: Font Color Incongruent	1.33	0.39	3.42	<.001***

Note. False memory frequency (Conservative) ~ (Condition + Font.Color)^2 + (1|Subject) + (1|Word). * $p < .05$; ** $p < .01$; *** $p < .001$

Table 2

Hypothesis 1. Liberally scored model of false memory frequency

	Estimate	Std. Error	z-value	*p*
(Intercept)	1.88	0.52	3.61	<.001***
Condition Implicit	-1.80	0.30	-5.90	<.001***
Font Color Incongruent	-1.02	0.30	-3.44	<.001***
Condition Implicit: Font Color Incongruent	1.30	0.40	3.28	.001**

Note. False memory frequency (Liberal) ~ (Condition + Font.Color)^2 + (1|Subject) + (1|Word). * $p < .05$; ** $p < .01$; *** $p < .001$

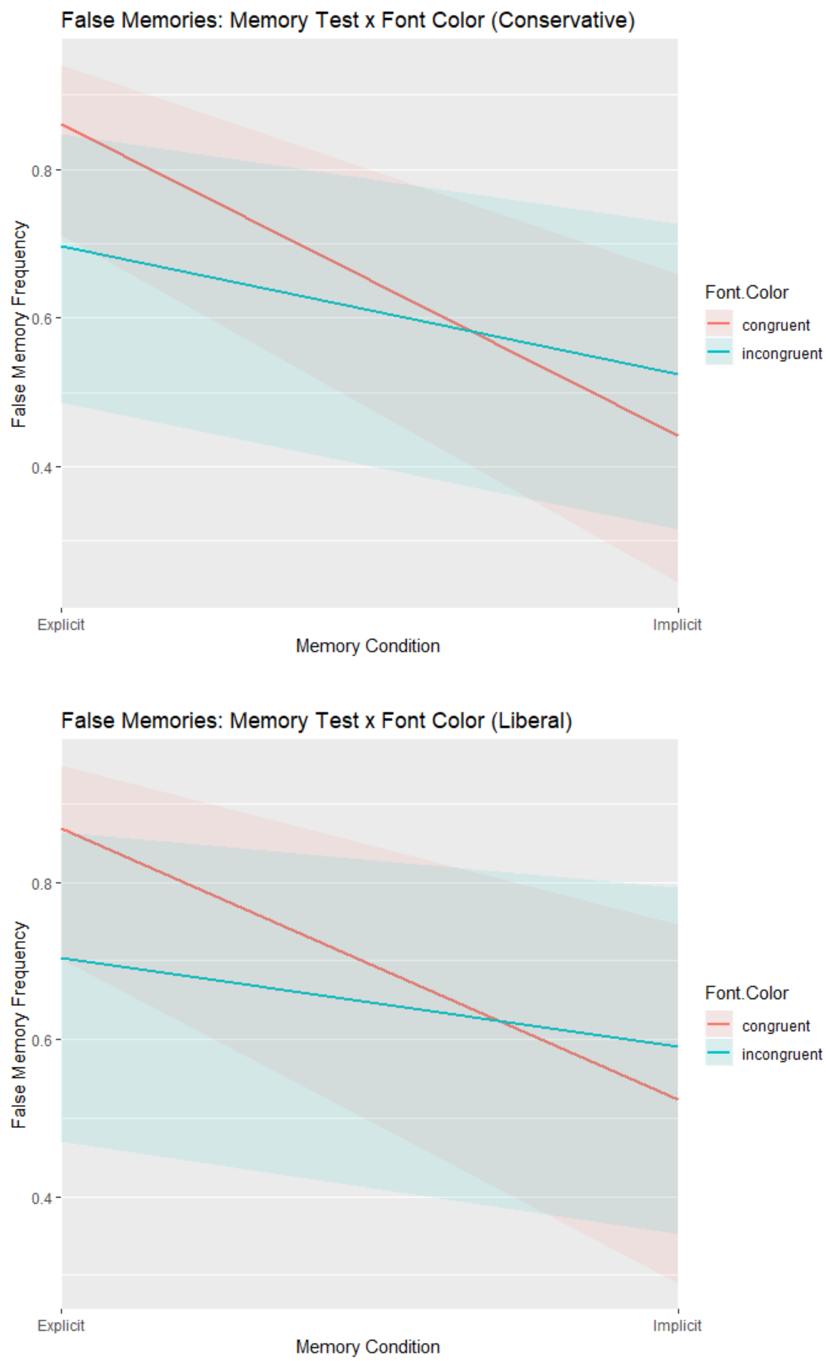

Figure 1. Hypothesis 1a. Interactions between memory condition and font color regarding false memory frequency, scored both conservatively and liberally.

Hypothesis 1b. The main effect for test condition, as part of the analysis from results heading Hypothesis 1a predicted that those in the implicit condition would have more false memories than those in the explicit condition.

Results from the mixed effects analysis showed that when scored conservatively (see Table 1), there was a significant difference in false memory frequency (b* = -2.07, *SE* = 0.30, *z* = -6.84, *p* <. 001), such that those in the implicit memory condition (*M* = 0.48, *SD* = 0.50) had significantly less false memories than those in the explicit memory condition (*M* = 0.75, *SD* = 0.43). The liberal scoring (see Table 2) showed the same relationship (b* = -1.80, *SE* = 0.30, *z* = -5.90, *p* < .001), such that those in implicit memory condition (*M* = 0.54, *SD* = 0.50) had significantly less false memories than those in the explicit memory condition (*M* = 0.75, *SD* = 0.43).

Hypothesis 1c. The main effect for font color condition, as part of the analysis from results heading Hypothesis 1a predicted that those in the congruent font color condition would have more false memories than those in the incongruent condition.

Results from the mixed effects analysis showed that when scored conservatively (see Table 1), there was a significant difference in false memory frequency (b* = -1.00, *SE* = 0.29, *z* = -3.40, *p* < .001) between those in the congruent condition (*M* = 0.65, *SD* = 0.48) and those in the incongruent condition (*M* = 0.60, *SD* = 0.49), such that those in the congruent condition had significantly more false memories than those in the incongruent condition. The liberal scoring (see Table 2) showed the same relationship (b* = -1.02, *SE* = 0.30, *z* = -3.44, *p* < .001), such that those in congruent condition (*M* = 0.67, *SD* = 0.47) had significantly more false memories than those in the incongruent condition (*M* = 0.63, *SD* = 0.48).

Hypothesis 2a. It was expected that those tested on their implicit memory would have more accurate memories if they were in the congruent font color condition, as compared to those in the explicit condition. For this model, the dependent variable was accuracy, while the fixed effects were memory test condition (explicit or implicit) and font color (congruent or incongruent) and were allowed to interact. The main effect results stemming from this analysis are reported under the results headings "Hypothesis 2b and 2c"

Results from the mixed effects analysis show that when scored conservatively (see Table 3), there was no significant difference in memory accuracy (b* = 0.04, *SE* = 0.15, *z* = 0.27, *p* = .78, Marginal R^2 = .14) between those in implicit memory condition (*M* = 0.29, *SD* = 0.45) and those in the explicit memory condition (*M* = 0.65, *SD* = 0.48) when the font color was congruent. The model was not found to be a good fit when compared to the null model ($X^2(1) = 0.07$, *p* = .78). The liberal scoring (see Table 4) showed the same relationship (b* = 0.19, *SE* = 0.15, *z* = 1.27, *p* = .21, Marginal R^2 = .08) between those in implicit memory condition (*M* = 0.37, *SD* = 0.48) and those in the explicit memory condition (*M* = 0.64, *SD* = 0.48) when the font color was congruent, as compared to incongruent font color conditions. The model was not found to be a good fit when compared to the null model ($X^2(1) = 1.60$, *p* = .21). The difference between conservative and liberal scoring were significantly different (*t* = -3.82, *p* < .001) for memory accuracy, such that when scored conservatively, there were far less accurate memories compared when scored liberally. Figure 2 shows that the interaction is supportive of what was expected, although insignificantly, such that those in the implicit memory condition had more accurate memories when also in the congruent font color condition as compared to incongruent font color conditions.

Table 3

Hypothesis 2. Conservatively scored model of memory accuracy

	Estimate	Std. Error	z-value	*p*
(Intercept)	0.71	0.18	4.00	<.001***
Condition Implicit	-1.75	0.10	-18.24	<.001***
Font Color Incongruent	-0.26	0.08	-3.40	<.001***
Condition Implicit: Font Color Incongruent	0.04	0.15	0.27	.78

Note. Interaction effects: Memory Accuracy (Conservative) ~ (Condition +Font.Color)^2 + (1|Subject) + (1|Word). Main effects: Memory Accuracy (Conservative) ~Condition + Font.Color + (1|Subject) + (1|Word). * p <.05; **p < .01; *** p < .001

Table 4

Hypothesis 2. Liberally scored model of memory accuracy

	Estimate	Std. Error	z-value	*p*
(Intercept)	0.69	0.19	3.61	<.001***
Condition Implicit	-1.28	0.09	-14.56	<.001***
Font Color Incongruent	-0.20	0.07	-2.68	.007**
Condition Implicit: Font Color Incongruent	0.19	0.15	1.27	.21

Note. Interaction effects: Memory Accuracy (Liberal) ~ (Condition + Font.Color)^2 + (1|Subject) + (1|Word). Main effects: Memory Accuracy (Liberal) ~ Condition + Font.Color + (1|Subject) + (1|Word). * p <.05; ** p < .01; *** p < .001

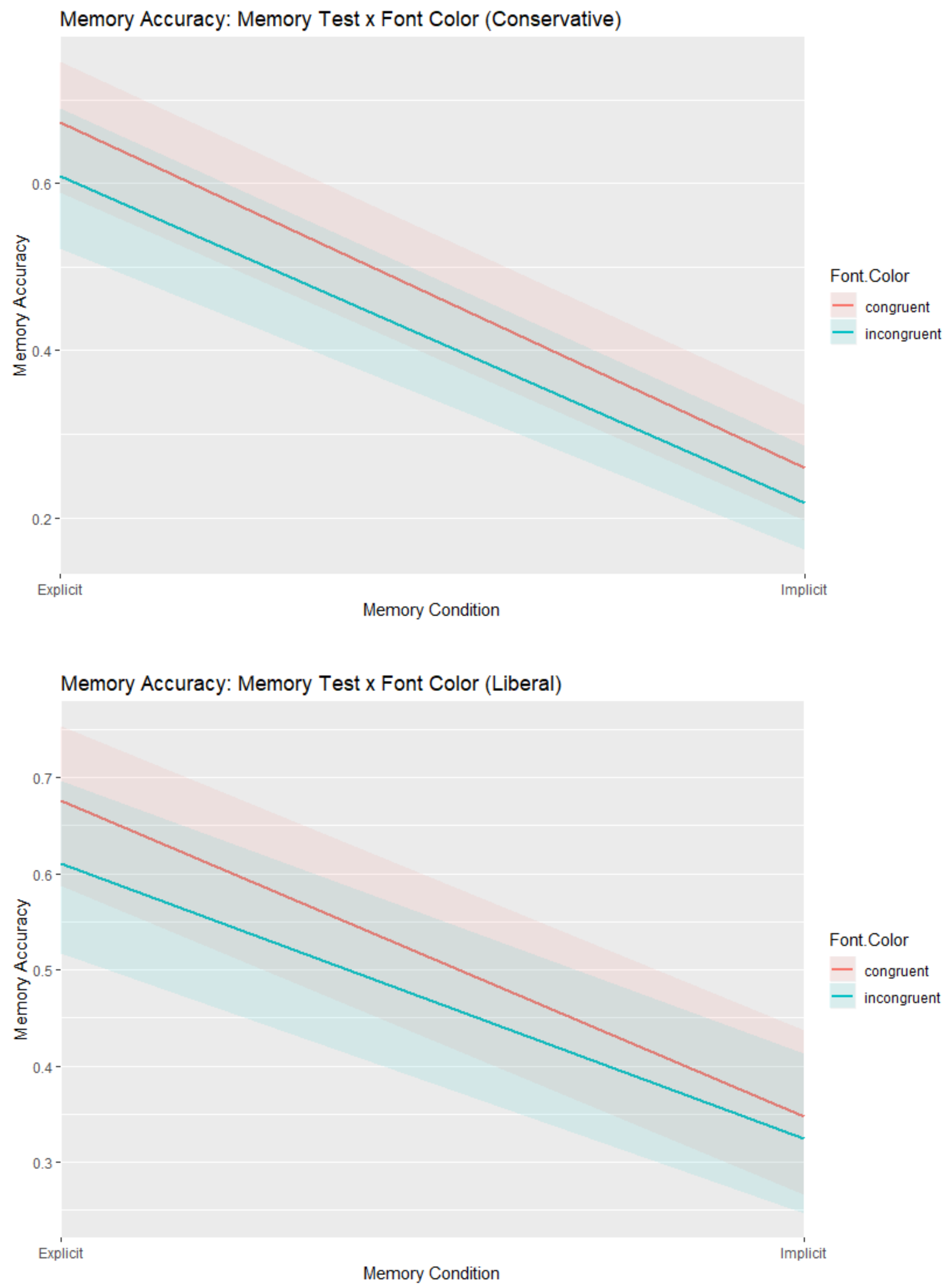

Figure 2. Hypothesis 2. Interactions between memory condition and font color regarding false memory frequency, scored both conservatively and liberally.

Hypothesis 2b. The main effect for test condition, as part of the analysis from results heading Hypothesis 2a predicted that those in the implicit condition would have more accurate memories than those in the explicit condition.

Due to the fact that the interaction was insignificant for the memory accuracy model, separate analyses were done with only the main effects, in order to get better fit model. Results from the analysis without the interaction showed that when scored conservatively (see Table 3), there was a significant difference in memory accuracy (b* = -1.75, *SE* = 0.10, *z* = -18.24, $p < .001$), such that those in the implicit memory condition (*M* = 0.27, *SD* = 0.44) had significantly less accurate memories than those in the explicit memory condition (*M* = 0.62, *SD* = 0.49). The liberal scoring (see Table 4) showed the same relationship (b* = -1.28, *SE* = 0.09, *z* = -14.56, $p < .001$), such that those in implicit memory condition (*M* = 0.36, *SD* = 0.48) had significantly less accurate memories than those in the explicit memory condition (*M* = 0.62, *SD* = 0.49).

Hypothesis 2c. The main effect for font color condition, as part of the analysis from results heading Hypothesis 2a predicted that those in the congruent font color condition would have more accurate memories than those in the incongruent condition.

Due to the fact that the interaction was insignificant for the memory accuracy model, separate analyses were done with only the main effects, in order to get better fit model. Results from the analysis without the interaction showed that when scored conservatively (see Table 3), there was a significant difference in memory accuracy (b* = -0.26, *SE* = 0.08, *z* = -3.40, $p < .001$), such that those in the implicit memory condition (*M* = 0.27, *SD* = 0.44) had significantly less accurate memories than those in the explicit memory condition (*M* = 0.62, *SD* = 0.49). The liberal scoring (see Table 4) showed the same relationship (b* = -0.20, *SE* = 0.07, *z* = -2.68, *p* = .007), such that those in implicit memory condition (*M* = 0.36, *SD* = 0.48) had significantly less accurate memories than those in the explicit memory condition (*M* = 0.62, *SD* = 0.49).

Exploratory Analyses

Exploratory analyses were done looking at the 3-way interaction between memory test, font color, and word type on memory accuracy, to see if there is a difference in memory accuracy for new and old words in both congruent and incongruent font colors, in both the implicit and explicit memory conditions. Similar analyses were not done for false memory frequency, because false memory frequency only analyzes responses to critical words. For this model, the dependent variable was accuracy, while the fixed effects were memory test condition (explicit or implicit), font color (congruent or incongruent), and word type (old or new) and were allowed to interact.

Results from the mixed effects analysis show that when scored conservatively (see Table 5), there was a significant interaction (b* = 1.69, *SE* = 0.36, *z* = 4.73, *p* < .001, Marginal R^2 = .19), such that both those in implicit memory condition (*M* = 0.34, *SD* = 0.48) and those in the explicit memory condition (*M* = 0.69, *SD* = 0.46) had more accurate memories for old words when the font color was congruent, compared to those in implicit memory condition (*M* = 0.30, *SD* = 0.46) and those in the explicit memory condition (*M* = 0.52, *SD* = 0.50) in the incongruent font color condition. However, those in the explicit memory condition (*M* = 0.71, *SD* = 0.45) had more accurate memories for new words when the font color was incongruent, compared to when the font color was congruent (*M* = 0.56, *SD* = 0.50). This effect was not seen for those in the implicit memory condition (*M* = 0.13, *SD* = 0.34), as they had more accurate memories for new words when in the congruent condition, as compared to the incongruent condition (*M* = 0.13, *SD* = 0.34). The model was found to be a good fit when compared to the null model ($X^2(4) = 118.56$, $p < .001$).

Table 5

Exploratory analysis. Conservatively scored model of memory accuracy

	Estimate	Std. Error	z-value	*p*
(Intercept)	0.38	0.32	1.18	.24
Condition Implicit	-2.30	0.23	-10.2	<.001***
Font Color Incongruent	0.76	0.18	4.27	<.001***
Word Type Old	0.54	0.39	1.38	.17
Condition Implicit: Font Color Incongruent	-1.10	0.31	-3.57	<.001***
Condition Implicit: Word Type Old	0.65	0.25	2.58	.01*
Font Color Incongruent: Word Type Old	-1.56	0.22	-7.14	<.001***
Condition Implicit: Font Color Incongruent: Word Type Old	1.70	0.36	4.73	<.001***

Note. Memory Accuracy (Conservative) ~ (Condition + Font.Color + Word Type)^3 + (1|Subject) + (1|Word). * $p < .05$; ** $p < .01$; *** $p < .001$

The liberal scoring (see Table 6) showed the same relationship (b* = 1.61, *SE* = 0.33, $z = 4.86$, $p < .001$, Marginal $R^2 = .12$), such that both those in implicit memory condition (*M* = 0.42, *SD* = 0.49) and those in the explicit memory condition (*M* = 0.69, *SD* = 0.46) had more accurate memories for old words when the font color was congruent, compared to when those in the implicit memory condition (*M* = 0.41, *SD* = 0.49) and those in the explicit memory condition (*M* = 0.52, *SD* = 0.50) were in the incongruent font color condition. However, those in the explicit memory condition (*M* = 0.71, *SD* = 0.45) had more accurate memories for new words when the font color was incongruent, compared to when the font color was congruent (*M* = 0.56, *SD* = 0.50). This effect was not seen for those in the implicit memory condition (*M* = 0.22, *SD* = 0.42), as they had more accurate memories for new words when in the congruent condition, as compared to the incongruent condition (*M* = 0.23, *SD* = 0.42). The model was found to be a good fit when compared to the null model ($X^2(4) = 111.18$, $p < .001$).

Table 6.

Exploratory analysis. Liberally scored model of memory accuracy

	Estimate	Std. Error	z-value	*p*
(Intercept)	0.39	0.34	1.13	.26
Condition Implicit	-1.75	0.20	-8.55	<.001***
Font Color Incongruent	0.77	0.18	4.26	<.001***
Word Type Old	0.55	0.42	1.31	.19
Condition Implicit: Font Color Incongruent	-0.88	0.28	-3.17	.001**
Condition Implicit: Word Type Old	0.47	0.23	2.02	.04*
Font Color Incongruent: Word Type Old	-1.59	0.22	-7.17	<.001***
Condition Implicit: Font Color Incongruent: Word Type Old	1.61	0.33	4.86	<.001***

Note. Memory Accuracy (Liberal) ~ (Condition + Font.Color + Word Type)^3 + (1|Subject) + (1|Word). * p <.05; ** p < .01; *** p < .001

Discussion

This study examined the relationship between the types of long term memory, encoding specificity, false memory frequency, and memory accuracy in an incidental learning situation. The design and hypotheses from the current study are largely based on that of McDermott (1997) and Dodd and MacLeod (2004). Broadly, the results of this study suggest that there is indeed a meaningful relationship between these variables that can be seen when information is learned incidentally.

Spreading Activation and Implicit Memory

In 2004, Dodd and MacLeod found that participants had significant levels of explicit false memories when DRM word lists were learned incidentally via a Stroop task. The creation of false memories in this study is attributed to the process of spreading activation, which occurs even when information is learned incidentally. The current study extended upon that of Dodd and MacLeod, with the addition of an implicit memory condition. What was found in the current study supports what was found by Dodd and MacLeod because we too were able to detect significant levels of explicit false memories when information was learned incidentally via a Stroop task.

In 1997, McDermott found that participants can be primed by DRM word lists to have significant levels of both perceptual and conceptual implicit false memories. The current study extended upon that of McDermott, with some differences in design. The most prominent difference between the studies is that McDermott (1997) did not compare implicit and explicit false memory rates. While she was able to detect the differences within conceptual and perceptual implicit false memories, she did not make comparisons to explicit false memories. Additionally, McDermott (1997) did not execute the learning of word lists in an incidental fashion. McDermott (1997) found that DRM word lists can effectively prime the implicit memory of participants, leading many researchers to continue studying implicit false memories. The results from the current study support what McDermott found, because we were able to successfully prime participants for perceptual implicit false memories, however we did not look into conceptual implicit memories.

Interestingly, the results from the analyses coinciding with Hypotheses 1b and 2b showed significantly less false memories and accurate memories for those in the implicit memory conditions. The relatively low amounts of implicit false memories and accurate memories seemingly contradicts what has been found by other researchers (e.g. Tajika et al., 2005). However, the results from the current study are consistent with the findings that implicit false memories can indeed be caused by priming of semantic associates (McDermott, 1997; McKone & Murphy, 2000).

There are several explanations for why our results regarding perceptual implicit false memories were smaller than expected. One explanation is that semantic priming may be more short-lived than other forms of priming, such as repetition priming (McBride, Coane, & Raulerson, 2006). Meade, Watson, Balota, and Roediger (2007) found that when there are more intervening steps between learning and implicit memory tests, less false memories occur in semantic priming experiments, compared to when there are less or no intervening steps between learning and memory test. These results are consistent with the theory that semantic priming is more short-lived, and thus, in order to test perceptual implicit false memories experimentally, there should be minimal intervening steps between learning and memory test. The present experiment had participants take a short, self-paced break in between the color identification task and the word-stem completion task, followed by intermediate oral instructions provided by research assistants. These intervening steps may contribute to the relatively low amount of implicit false memories found. Additionally, the fact that in the current study the DRM word lists were not presented in their traditional blocked fashion, this may further interrupt the semantic priming between learning and test. Participants were not shown each list in its entirety before being shown another list, and were instead shown equivalent associates from each list one after the other, in descending order from strongest to weakest associate. The way the lists were presented may have made semantic priming less detectable because there may have been more intermediate stimuli being shown between the learning and recall of the information associated to a given word list.

Additionally, McBride et al. (2006) puts forward another possible explanation for our results. In implicit false memory experiments, participants are more likely to begin to explicitly retrieve information if they connect the study phase (even though the aim was to study the information incidentally) to the test phase. This is a big issue to consider, as it may provide alternative explanations for what was found in the current study. For example, if participants in the implicit condition began to recognize word stems as belonging to words that were also present during the color identification task, they may begin completing the stems with those words explicitly (intentionally). Also, during the memory test if there are a small amount of non-related filler words present participants are more likely to consciously recognize the relationship between the words during the learning phase and memory test. Thus, in the present study as well as others (Tajika et al., 2005), 8 filler words in the memory test may not be enough to keep participants in the dark as to the true nature of the experiment. With only 8 filler words during the implicit memory test, it is very possible that participants were able to see the connection between the items from the learning phase of the experiment and therefore responded explicitly to the memory test (McBride et al., 2006; Tse & Neely, 2005).

Furthermore, something that is very important in false memory experiments is lexical activation. In order for lexical activation to occur, the lexical form of a word must be present. This means that the word in its entirety must be present, whether it be presented auditorily or visually in text form. If the lexical form of a word is indeed present during learning in perceptual implicit false memory experiments, then it may be repetition priming, and not semantic priming that is at work. To reiterate from earlier in this paper, repetition priming is the memory facilitation that occurs when an item has already been presented at least once. For example, if one is presented with the word “window” during the learning phase of an experiment, and is then tested with the presentation of the word “window” again (i.e. the item is repeated, hence “repetition” priming), the person has been primed by the presentation of the same word twice, thus facilitating their memory for the item. It is common practice in some false memory experiments to actually present the critical lure word to some conditions during the learning phase, in order to test both semantic and repetition priming (e.g. McDermott, 1997). In these cases, the lexical form of the word is actually present during the learning phase of the experiment and therefore, lexical activation occurs and often results in a large amount of priming (McDermott, 1997). For example, if some participants were presented with the word “window” during the learning phase and others were only presented with semantic associates of the word window (e.g. “shade”, “ledge”, “pane”), those presented with the actual word have experienced repetition priming from the lexical activation of the word “window” at both learning and test, while those who were presented with associates have experienced semantic priming.

Additionally, researchers have found that the implicit memory system may not be as susceptible to semantic activation, compared to lexical activation (McBride et al., 2006; Roediger & McDermott, 1993). What this means is that in many implicit false memory experiments, it may be mainly the lexical activation via repetition priming and not semantic activation via semantic priming that resulted in significant levels of priming on implicit memory tests. To further expand on this notion, Lovden and Johansson (2003) found that verbal articulation mediated the priming for implicit false memories. Their results suggest that lexical activation is an important factor to consider when testing the creation of implicit false memories. Therefore, the relatively low amount of implicit false memories and accurate memories in the present study may be due to the fact that lexical activation during the word stem completion task did not occur. This was not an issue with explicit false memories because the explicit memory system is more susceptible to semantic activation.

It is important to note that there were a significant amount of implicit false memories, as found in the results coinciding with Hypotheses 1b, just far less than expected and far less than the explicit memory condition. The fact that there was a degree of successful priming for implicit false memories is likely due the monitoring component within the activation-monitoring theory, proposed by Gallo and Roediger (2002). To reiterate, the monitoring process causes false memories due to errors in identifying the source of activation that led to a memory. Participants in this study may have made source monitoring errors when going through the word stem completion task. That being said, in order for this to occur, explicit contamination of the implicit memory would be necessary, because monitoring does not occur within the implicit memory system. This means that it is possible, as mentioned above, that participants began consciously retrieving words from the color identification task to complete the word stems, negating the implicit nature of the task.

Encoding Specificity

Encoding specificity states that when conditions during learning and retrieval are congruent, memory is facilitated. This concept has been supported by numerous studies (Godden & Baddeley, 1975; Grant et al., 1998; Tulving, 1974; Tulving & Thompson, 1973), but has been understudied regarding false memories. One would think that false memories should behave in a similar manner as accurate memories, but this may not be the case.

The results of the current study found that encoding specificity was supported in regard to false memory frequency (Hypothesis 1c) and memory accuracy (Hypothesis

2c). Those in congruent conditions did have more false memories and greater memory accuracy than those in incongruent conditions, regardless of test condition. These results are in line with what was expected and what past research has found regarding encoding specificity (Godden & Baddeley, 1975; Grant et al., 1998; Tulving, 1974; Tulving & Thompson, 1973). This suggests that explicit and implicit accurate and false memories are prone to the effects of encoding specificity. There is a lot of support for the notion that false memories and accurate memories behave very differently, but the results from the current study suggest that perhaps the two are not as different as we may think.

However, more interesting than the main effects of this study was the interaction effect that was found between explicit and implicit false memories in Hypothesis 1a. In this experiment, participants in the implicit memory condition had significantly more false memories when they were also in the incongruent color condition. Not only does this seem to contradict what one would expect, given what has been found in support of encoding specificity, but it seems to suggest that perhaps the opposite is true for implicit false memories. The results from the current study suggest that incongruence facilitates the creation of implicit false memories, more so than congruence, despite the findings that implicit false memories are indeed context-dependent, even more so than explicit false memories (Tajika et al., 2005).

Tajika et al. (2005) found when the incidental learning of information is more context-rich, participants have significantly more implicit false memories, even more so than those in the explicit memory condition who were also in the context-rich conditions. These results largely fueled my hypothesis that the implicit memory condition will have more false memories in congruent font color conditions. However, there are differences between the two experiments that may contribute to our differences in results. Tajika et al.'s manipulation of context (2005) was much stronger than that of the current study. Tajika et al. (2005) utilized different instructions to participants in order to enhance the context associated with learned DRM word lists (i.e. imagery instructions: imagine the word in your mind or imagery plus writing instructions: imagine the word in your mind and write it down). The participants who received more context when learning the word lists (i.e. imagery plus writing) had far more implicit false memories than those who received less context (i.e. imagery). This may be why they found such a large difference between explicit and implicit false memories. Therefore, a potential explanation for what was found in the current study is that perhaps the context manipulation in this experiment was too weak.

Although previous research uses font color as a way of manipulating encoding specificity (Vaidya et al., 1998), more recent research has put forward the idea that stronger manipulations of context are needed (Smith, Handy, Hernandez, & Jacoby, 2018). Smith et al. (2018) claim that weak manipulations of context make it difficult to detect contextual effects on implicit memory, because the contextual similarities are not enough for the subconscious to pick up on. Thus, perhaps it can be assumed that implicit false memories are more context-dependent than explicit false memories, but more evident contextual cues are needed. If this is the case, it would seem that this effect would be a similarity between false and accurate memories. This may explain why the present findings contradict Tajika et al. (2005), because those researchers used more rich contextual manipulations in their study.

Limitations

This study was experimental with great internal validity. Thus, there is a trade-off at play, resulting in lower external validity. This may mean that there is low generalizability to real-world experiences of false memories. Additionally, new research suggests that perhaps a stronger encoding specificity manipulation may have been needed in this study to really explore the effects on implicit memory (Smith et al., 2018). A way to combat this limitation in future research may be to use contextual manipulations that are in line with what was used in Tajika et al. (2005). Additionally, it has also been found that often times in implicit memory tests, participants often become test-aware (McBride et al., 2006), especially when a small amount of filler words are presented during the memory test. This research suggests that it is possible that when participants engage in implicit memory tests, they may become test-aware, and thus being to consciously retrieve information, rather than unconsciously. This is an issue because it completely negates the implicit intention of the experiment. Explicit contamination can lead to misleading results, as discussed above. To avoid this limitation in future research, more stringent manipulations to discourage conscious retrieval may be required. Another option is a post-test question asking participants if they became test-aware. Researchers can then remove the participants who self-identified were test-aware from the analysis.

Additionally, due to the fact that each word list was associated with a specific color and we did not want participants to catch on to this, we were not able to present the

DRM word lists in the traditional fashion. In most studies, DRM lists are presented in a blocked fashion with each list presented completely from strongest to weakest associate. The current study presented the strongest associates from each list first, followed by the second strongest from each list, etc until each list was presented completely. The order of the presentation of each associate of the same strength for each list was counterbalanced to avoid the emergence of patterns. Although this deviation from what is normally done was necessary, it is a limitation because it could have affected the results, because semantic priming is short-lived (McBride et al., 2006). The clustered presentation of the word-lists may not have resulted in the desired semantic priming because the words were not presented in the traditional blocked fashion, therefore the short-lived semantic priming may have been dormant by the time the memory test occurred.

Implications

Although indirectly, this research adds to the pressing problem of false eyewitness testimonies in the United States. False eyewitness testimonies are the leading cause of wrongful conviction in the United States. Since forensic DNA tests in criminal cases started being used in the 1990s, hundreds of people have been exonerated. Of those people, over 75% were charged due to false eyewitness testimonies (Wells & Olson, 2003). Unfortunately, some convicts have already served years worth of their sentences or have even been given a death sentence before they were exonerated by DNA evidence. These facts are staggering and force one to consider why eyewitness testimonies are still being used in criminal trials, given all of the research that has been done since the 1970s. After her work researching false memories, Psychologist Elizabeth Loftus served as an expert witness in several court cases, using her research to explain why eyewitness testimonies should not be used for convictions, or should at least be used with caution. The work of Loftus and other false memory researchers shows just how easy it is for false memories to occur, deeming our memories of events extremely unreliable (Loftus & Palmer, 1974; Loftus & Pickrell, 1995; Roediger & McDermott, 1995). The current study adds to this literature because it successfully created both explicit and implicit false memories in participants and investigated the effects of encoding specificity.

Furthermore, many of the methods used by law enforcement and courts have been shown to increase the frequency of false memories (Douglass & Steblay, 2006). More specifically, the post-identification feedback effect is the idea that the comments provided by line-up administrators during identification of perpetrators from a line-up can greatly influence the likelihood of a false identification (Douglass & Steblay, 2006). For example, if a witness were to identify a perpetrator from a line-up and the law enforcement officer confirmed "yes, you've identified the correct suspect", this greatly inflates the witness' post-identification confidence later on in the trial.

Other factors that are under the control of law enforcement can influence the rate of false eyewitness testimonies, such as the selection of the fillers used in a line-up (Wells, Rydell, & Seelau, 1993), blind administration of the line-up (Douglass, Smith, & Fraser-Thill, 2005), ensuring that witnesses are aware that the actual perpetrator may not be present in the line-up (Malpass & Devine, 1981; Steblay, 1997), presenting potential perpetrators in a sequential rather than simultaneous manner (Steblay, Dysart, Fulero, &

Lindsay, 2001), and obtaining a statement from witnesses as to how confident they are at the time of identification (Luus & Wells, 1994).

Researchers have provided recommendations and guidelines to law enforcement in order to minimize the frequency of false identification, many of which have not been adhered to. The false memory research that has and is being done by psychologists should be taken into account more seriously in order to prevent more wrongful convictions. Additionally, further false memory research should be conducted and made public so we can try to correct this issue in our law enforcement and judiciary system.

Future Directions

In most cases when an individual is a witness in a criminal trial, the information that they are being explicitly asked about was often learned incidentally, as they were likely not attempting to memorize the information present in the environment during a crime. Thus, in order to learn more about false memories that can lead to false eyewitness testimonies, more research on false memories in incidental learning situations should be done, with the addition of aspects to make it more generalizable to criminal trials. For example, when reflecting on information when you are being questioned by police, there is a lot of emotion involved, such as stress and fear. These emotions have an impact on the retrieval of the information that was not present in the current study.

Additionally, more research needs to be done regarding the differences among explicit and implicit false memories and how they are related to context, as many of the findings have been inconsistent. The current study found that encoding specificity effects are great for false memories, but the limitations of the study need to be addressed in future research. In regards to criminal investigations, one may interpret the interaction that was found for explicit false memories as indicating that incongruent conditions should be implemented to ensure a smaller likelihood for false recognition. This may mean taking witnesses away from the crime scene for interrogations to reduce the likelihood of false memories occuring, but this too may be problematic as there may be detriments to real memory recollection in an incongruent context.

Conclusion

In summary, the present study added to the false memory literature by examining the difference between false memory frequency and memory accuracy between the different types of long-term memory and contextual congruence in incidental learning situations. The incidental learning of DRM semantically associated word lists resulted in significant amounts of both explicit and implicit false memories as well as explicit and implicit accurate memories. There were differences in the rates of these variables when font color was either congruent or incongruent between learning and test, such that, when in the implicit memory condition, there were significantly more false memories when the font color was incongruent. When in the explicit memory condition, there were significantly more false memories when the font color was congruent, as was expected. Interestingly, the interaction was not significant for memory accuracy, such that there was no significant difference between explicit and implicit memory accuracy across the font color conditions. Overall, the explicit memory condition had significantly more false memories and accurate memories than the implicit condition. Overall, the congruent font color condition had significantly more false and accurate memories than the incongruent condition.

The literature regarding contextual effects on implicit false memories remain inconsistent. While some studies show significantly greater effects on the implicit memory system compared to the explicit system (Tajika et al., 2005), this study shows the opposite effect. Several explanation for these results are put forward, such as the amount of intermediate steps between learning and test, the amount of filler words in the memory test, the importance of lexical activation, (McBride et al., 2006) and greater contextual manipulations may be required to uncover the true effect of context on implicit false memories (Smith et al., 2018). Future research should address these factors, as well as implement more stringent regulations in order to avoid test-awareness in implicit memory tests.

The present results help add to the body of research that has been done by cognitive scientists regarding the phenomenon of false memories. False memories are import to research because they can have extremely detrimental outcomes, such as wrongful convictions due to false eyewitness testimonies. The true differences between implicit and explicit false memories remain largely unknown and must be investigated further, in order to come to a more well-rounded understanding of false memories.

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Appendix A

Critical Words With List Items 1 to 15

Words from (Stadler et al., 1999), presented in order from strongest to weakest associate to critical word (presented in all capital letters). Items that will be presented in the memory tests are signified with asterisks.

*SLEEP: bed, *rest, awake, *tired, dream, wake, snooze, *blanket, *doze, slumber, snore, nap, *peace, *yawn, drowsy

*WINDOW: door, *glass, pane, *shade, ledge, sill, house, *open, *curtain, frame, view, breeze, *sash, *screen, shutter

*ROUGH: smooth, *bumpy, road, *tough, sandpaper, jagged, ready, *coarse, *uneven, riders, rugged, sand, *boards, *ground, gravel

*SMELL: nose, *breathe, sniff, *aroma, hear, see, nostril, *whiff, *scent, reek, stench, fragrance, *perfume, *salts, rose

Appendix B

Open ended answers result in a variety of responses. For the liberal scoring of the data, accepted alternatives were credited as accurate or indicative of a false memory, see table below. For conservative scoring, only the target word was credited as accurate or indicative of a false memory.

Target word	**Accepted alternatives**
Breathe	Breath
Tired	Tire, Tiredness, Tires
Bumpy	Bump
Salts	Salt, Salty
Boards	Board
Anger	Angry
Smell	Smelly, Smelling, Smelled
Rest	Rested, Restful
Yawn	Yawning
Sleep	Slept
Open	Opened, Opening
Shoe	Shoes
Rough	Rougher, Roughly
Aroma	Aromatic
Glass	Glasses
Scent	Scented
Doze	Dozing
Window	Wind

Words with the same base word, but different overall meaning are not accepted alternatives, such as “bumper” instead of “bumpy”

Words that are misspelled are accepted alternatives if they attempted to spell the correct word or one of the other accepted alternatives above