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Effects of Pictorial and Imagery Encoding on False Memories

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EFFECTS OF PICTORIAL AND IMAGERY ENCODING ON FALSE MEMORIES

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ABSTRACT

Prior research demonstrates that viewing matched pictures is ineffective in reducing false memories for related lures that have not been previously externally presented during the experiment. However, other types of visual processing, such imagery encoding, have been shown to reduce false memories when evaluated from paradigms where the critical item is also thought to be internally activated, such as when using DRM lists. The prior work showing that imagery encoding can reduce false memories when using DRM lists may be confounded by a potential mismatch between the mentally-generated image and the visual word. Using a category associate procedure, as opposed to DRM lists, may help provide a more accurate depiction of the effects of visual processing on false memories for related lures. The purpose of this dissertation was to evaluate the effects of different visual encoding conditions on false memory while using a category associate procedure. In two pilot experiments, we demonstrated that imagery encoding was effective in reducing false recall. In a third experiment, we manipulated the test instructions (standard v inclusion) to test the predictions of two key theories (impoverished relational-encoding and distinctiveness heuristic) used to explain the effects of varying levels of visual processing on false memory. The present set of experiments demonstrated that the type of visual stimuli has a unique effect on memory performance. Viewing items pictorially may help to increase the rate of correctly recalled items. Additionally, engaging in imagery may help to not only increase the rate of correctly recalled items, but also reduce the rate of falsely recalled items. Future work evaluating the potential theoretical mechanisms of these effects is warranted.

LIST OF ABBREVIATIONS AND SYMBOLS

ANOVA, Analysis of Variance

DRM, Deese/Roediger-McDermott

ES, Effect size

e.g., For example

F, F-value from analysis of variance

i.e., That is

IPNP, International Picture Naming Project

M_{age}, Mean age

M_{diff}, Mean difference

η_p^2, Partial eta-squared

n, Sample size for a subgroup

p, P-value

SD, Standard deviation

SPSS, Statistical package for the social sciences

v, versus

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INTRODUCTION

The ability to accurately remember information plays an important role in reliving past experiences and shaping current and future behaviors (Albarracin & Wyer, 2000). Although memories are often accurate, false memories do occur (Scoboria, Wade, Lindsay, Azad, Strange, Ost & Hyman, 2017); indicating something happened or occurred when in fact it did not would be evidence of having a false memory.

This introductory chapter will provide an overview of false memory research; review theories to explain why false memories may be reduced when studying information as a picture; and discuss the results from several experiments in our lab – and other labs – demonstrating that false memory rates may vary not only as a function of the way in which the information is presented (e.g., visual or auditory), but also based on the source of the false memory (e.g., internal v external). After demonstrating that pictorial encoding is generally ineffective in reducing false memories from internally-derived sources when using category associate paradigms, the subsequent text will highlight emerging research showing that imagery encoding may be effective in reducing internally-derived false memories from other paradigms, such as pragmatic inference approaches. This will lead into Chapter 2 (Addressing the Gaps in the Literature), providing a more detailed rationale for comparing the effects of pictorial and imagery encoding on internally-derived false memories for category associate paradigms.

History of False Memory Research

Referred to by many as the first experimental study in memory, Ebbinghaus conducted a series of experiments in 1885 that led him to develop the forgetting curve (Ebbinghaus, 1964). Then shifting from a quantity-oriented approach (factors that affect the amount of remembered information) to a quality-oriented approach (factors that affect the accuracy of remembered information), Kirkpatrick, in 1894, performed what is considered to be the first laboratory experiment on false memory (Kirkpatrick, 1894). In this study, Kirkpatrick employed a list-learning paradigm[1] by exposing students to a series of words they were later asked to recall. A week later, many participants falsely recalled semantically related words that were not on the list. For example, instead of accurately recalling "*spool*", "*thimble*", and "*knife*", respectively, some participants recalled "*thread*", "*needle*", and "*fork*."

Following the 1894 experiment by Kirkpatrick, a spate of studies, evaluating different false memory paradigms, were conducted. Binet, in 1900, and Stern, in 1910, demonstrated that introducing misleading information in the form of questions or suggestions distorted memory among children. In 1932, Bartlett took a naturalistic approach to study false memory by using more complex materials rich in meaning and relevant to everyday situations (e.g., stories about a war).

In the late 1950's, when the field of cognitive psychology emerged, a more quantitative approach was used to study false memory. In 1959, Deese demonstrated the importance of *association*[2] on eliciting false memories, and then in the 1970's to the 1990's, Loftus and colleagues (and others) demonstrated that introducing misinformation after a study episode

[1] A list-learning paradigm involves learning a list of items (e.g., words), with the list often repeated multiple times and multiple lists frequently used. After this learning procedure, participants complete a memory test (e.g., recall or recognition) to evaluate their memory performance.

[2] Non-presented items that are associated with studied items are more likely to be falsely recalled than non-associated items.

influenced later reasoning and judgement, leading to false memories. For example, after watching a video of a traffic accident that depicts a "stop" sign, participants are subsequently asked how fast the car was travelling when it passed the "yield" sign. Participants often report faster speeds when probed with the wrong information (the "yield" sign) and appear to be unaware of the conflict between the initial account (the "stop" sign) and the subsequent misleading question (the "yield" sign) (Loftus, Miller & Burns, 1978). Further, even when such misinformation is corrected (e.g., later informed that it was a "stop" sign in the video), participants may continue to render false memories. This may result from *causal-based inference errors*, which occurs when inferences are drawn from the information before it was corrected. In such situations, these inferences are subsequently incorporated into their memories and can become part of their knowledge base (Butler, Dennis & Marsh, 2012). Other inference-based memory errors include *schematic gap filling errors*. This occurs when people compensate for their failure to recover details of a memory by drawing inferences and then mistaking these inferences for information they actually experienced (Bower, Black & Turner, 1979).

In the 1990's, Roediger and McDermott (1995) revived the 1959 work by Deese, now referred to as the Deese/Roediger-McDermott (DRM) paradigm. After being exposed to list items (e.g., bed, rest, tired) that are semantically related to an unpresented, critical item (e.g., sleep), individuals often falsely recall or recognize the critical item. Falsely recalling such critical items occurs at a rate similar to the studied items (for a review, see Lampinen, Neuschatz & Payne, 1998).

Studies employing semantic associates in a recall or recognition task are not the only approaches to studying false memory in a list learning paradigm. An alternative to semantic associates includes a procedure involving category associates. For example, in 1988, Hintzman presented participants with a list of words (e.g., booklet, pamphlet, comic book, magazine) from several categories (e.g., reading material) of familiar nouns. Hintzman found that exposure to category exemplars during study led to greater false recognition of related, non-studied exemplars. A false memory effect for category associates has also been observed when using pictures as the study materials. For example, Strack and Bless (1994) presented participants with images of objects (e.g., hammer, saw) from the same category (e.g., tools) and showed that participants exhibited a category exemplar false recognition effect by indicating that they recognized the word “tool”, which was absent from the study list.

Within the 21st century, current trends in false memory research have evaluated how false feedback leads people to change their beliefs of experienced events, as well as change their preference for related situations (Bernstein, Scoboria, & Arnold, 2015). Other recent work has evaluated how some aspects of modern life (e.g., sleep deprivation) may increase the likelihood of having false memories (Frenda, Patihis, Loftus, Lewis & Fenn, 2014). For a more thorough detail of recent trends in false memory research, the reader is referred to work by Laney and Loftus (2018).

Presentation Modality

Although false memories are very robust, various presentation format manipulations have been shown to be effective in reducing false memories. For example, compared to a condition in which participants only hear the word, false recall and recognition rates are reduced following visual presentation of study items/words (Smith & Hunt, 1998). Further, false recognition rates are also reduced after studying pictures when compared to visual words (Israel & Schacter, 1997). The following narrative will discuss two potential theoretical accounts (impoverished relational encoding and distinctiveness heuristic) for why pictorial encoding may reduce false memories.

Theoretical Explanations of the Presentation Modality Effect

Impoverished Relational-Encoding

Studying distinctive information, such as pictures,[3] may disrupt the encoding of relational or associative information (Hege & Dodson, 2004). Conversely, studying distinctive information may increase memory for item-specific information, and as a result, the critical lures may elicit less familiarity following picture encoding. This enhanced item-specific memory and decreased relational memory for pictorial encoding may decrease the likelihood of falsely recalling or recognizing the critical lure. In support of this theoretical account, Arndt and Reder (2003) presented words in the same font (e.g., candy, sugar) or a different font (e.g., **candy**, SUGAR). When items are presented in a different font, processing is directed toward item-specific features and away from relational features, thus, reducing the activation of the critical item. Indeed, Arndt and Reder showed that false recognition was lowest in the different font condition.

Distinctiveness Heuristic

According to the source monitoring framework (Johnson et al., 1993), memories are not encoded with a label indicating their origin. Rather, decision-based processes are implemented to evaluate the source of the memory (Dodson & Schacter, 2001). Distinctiveness heuristic, a general class of metacognitive strategies, refers to the decision rule, implemented at the point of memory retrieval, where the absence of memory for expected information is evidence for the

[3] Note, pictures themselves may not necessarily be distinctive. What determines this distinctiveness is the cognitive processing that occurs when viewing/studying such information (Hunt, 2013).

event's nonoccurrence (Hege & Dodson, 2004). Thus, this monitoring strategy depends on an individual's meta-memorial beliefs about what ought to be remembered (Hege & Dodson, 2004).

One approach to evaluate a theoretical mechanism is to create a situation that reduces the likelihood of using that mechanism. For example, utilizing a within-subject design may render difficulty in utilizing the distinctiveness heuristic. For a within-subject design, in which participants encode both pictorial and word stimuli, there is no longer a single type of stimuli that is solely diagnostic of the tests item's oldness or newness. In support of the distinctiveness heuristic, Dodson and Schacter (2001) and Schacter, Israel and Racine (1999) demonstrated that a within-subject design attenuated the presentation modality effect. However, as discussed by Dodson and Schacter (2002), it is unclear as to whether, in a within-subject design, participants abandon the use of the distinctiveness heuristic, or rather, they fail to use it successfully (e.g., they may apply a global heuristic to all of the test items).

Another approach that has been used to evaluate the distinctiveness heuristic is to implement inclusion recognition instructions at test. These instructions inform participants to endorse both studied items as well as related items that were associated with the theme of the study items. With these inclusion instructions, there should be no need to utilize the distinctiveness heuristic because the related lures should be recognized as old. As such, inclusion instructions should disengage post-access monitoring. In support of this, Schacter et al. (2001) observed a decreased rate of false memories for pictorial encoding when utilizing standard instructions, but employing inclusive instructions attenuated this effect. This effect has been replicated for recognition but not recall tests (Hege & Dodson, 2004). However, as discussed by Smith, Hunt and Dunlap (2011), the amount of time allowed to complete the recognition task may influence the effect of inclusive instructions on the presentation modality effect.

Source of False Memory

Although picture presentation has been shown to consistently reduce false memories in the DRM paradigm, Smith and Hunt (2020) provided evidence that this pattern of results may be due to the fact that many of the DRM word lists are abstract and therefore do not have a well-matched picture. For instance, in the DRM materials, a line drawing of a tongue with a spot on the tip of the tongue is assigned the word label *taste*, and it could be perceived as *tongue*, *spot*, *mouth* or *lips*, as opposed to *taste*. In this scenario, participants may engage in additional elaborative processing[4] to connect the word they hear ("taste") with the picture. To evaluate the influence of study materials (word v pictures) and the match between the auditory target and visually presented material, Smith and Hunt (2020; Experiment 1) randomized participants into one of four conditions, including *auditory only* (only heard word), *matched word* (heard word and saw same visual word; e.g., heard the word "taste" and saw the word "taste"), *picture* (heard word and saw picture of word; e.g., heard the word "taste" and saw a picture of a tongue), and *normative word* (heard word and saw most frequently generated normative label[5]; e.g., heard the word "taste" and saw the word "tongue"). The *picture* and *normative word* conditions decreased false memory, suggesting that pictures may not be necessary to decrease false memories, but rather, the mismatch between auditory and visual processing may decrease false memories.

To separate the effects of elaboration due to a mismatched word and picture, Smith and Hunt conducted additional experiments using category exemplars at study as these involve concrete words for which well-matched pictures could be obtained. Smith and Hunt (2020;

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[4] Elaborative processing defined here as the breadth or extent to which a stimulus/item is analyzed (Marks, 1989), and involves processing that is salient, or applicable to the event, and that specifies the item or event more uniquely (Craik and Tulving, 1975).

[5] In a separate norming study, Smith and Hunt (2020; Appendix A) showed the pictures for the DRM words alone (i.e., the picture was shown without the auditory words) and asked participants to provide a word that described what was depicted in the picture.

Experiment 2) also demonstrated that pictures may not be sufficient to reduce false memories. Participants were randomized into one of four conditions, including *auditory only* (only heard word), *matched word* (heard word and saw the same visual word; e.g., heard the "banana" and saw the word "banana"), *matched picture* (heard word and saw picture of word; e.g., heard the word "banana" and saw a picture of a banana), and a *related picture* (heard word and saw picture related to the word; e.g., heard the word "banana" and saw a picture of a monkey). The key finding was that matched pictures did not reduce false memories relative to the auditory only condition.

While Smith and Hunt (2020) provide evidence that using matched pictures do not reduce false memories in category lists, other research has demonstrated a reduction in false memory when using concrete words and matched pictures. For example, Dodson and Schacter (2002) used a running recognition test in which lures are presented repeatedly at test, requiring the individual to differentiate multiple intra-experimental externally presented sources of information (i.e., the critical lures repeatedly presented at test versus items presented at study) and found that presenting matched pictures at study reduced false alarms to the repeated lures.

Gallo, Weiss and Schacter (2004) used a criterial recollection test to evaluate the effects of studying matched pictures on false memory. This task involves studying items as pictures, red words, or as both pictures and red words. At test, participants are asked to remember items that were presented in a particular modality. For example, those in the picture test condition are asked to respond "old" to items presented as a picture, regardless of whether that item was also represented as a red word. Similarly, those assigned to the red word test condition are instructed to respond "old" to items only represented as a red word during the study phase. Critical lures are items pre-exposed during the study session, but not inclusive of items that they are instructed to remember from a specified modality. For example, a criterial exclusion error would occur if, in the red word test condition, a participant responds “old” to an item presented only as a picture in the study phase, and similarly, an exclusion error for the picture test condition would occur by responding “old” to an item presented only as a red word during the study phase. Gallo et al. demonstrated that recognition errors to these critical items are reduced on the picture test when compared to the red word test.

In two experiments, our laboratory replicated the findings of Smith and Hunt (2020), Dodson and Schacter (2002), and Gallo et al. (2004). Similar to Smith and Hunt, in our first experiment, we showed that matched pictures at study did not reduce false memories for related items (presented once or twice). Further we showed that – similar to Dodson and Schacter – matched pictures at study did not reduce false memories for unrelated lures presented once, but did reduce false memories for repeated unrelated lures.

In our follow-up experiment, using a criterial recollection task as done in Gallo et al. (2004), participants studied words in black ink followed by a picture representing that word or by the same word but shown in red ink. Following the study phase, participants completed a recognition test, either a standard test, picture test, or a red word test. Two types of false recognition errors can occur on the criterial recollection test, namely traditional false alarms and exclusion errors. Traditional false alarms occur when participants incorrectly respond “old” to a new item that was not presented during the study phase. Thus, these traditional false alarms involve confusion over extra-experimental information; *extra-experimental* in that these were not presented during the experimental study phase or previously during the test phase.

In addition to traditional false alarms, and as described above, for the picture and red word tests, a criterial exclusion error occurs when an individual incorrectly responds “old” to an item that was studied in a format not specified in the test instructions (e.g., on the red word test, responding "old" to an item studied as a picture, and on the picture test, responding "old" to an item studied as a red word). These exclusion errors represent confusion over two intra-experimental external sources; *intra-experimental* in that the critical lures were presented during the study episode and *external* in that the critical lures were presented externally. Our findings demonstrated lower exclusion errors on the picture test when compared to the red word test, suggesting that pictures may help to reduce false memories when derived from external sources. We did not, however, observe differences in traditional false alarm rates between the picture and red word test conditions. As stated, traditional false alarms represent confusion between extra-experimental information that was not externally presented during the study episode. Thus, traditional false alarm errors occur from confusion over internal sources.

Summarily, research by Gallo et al. (2004), Dodson and Schacter (2002), and our lab's recent experimental work demonstrates that matched pictures are effective in reducing false memories when derived from intra-experimental external sources (e.g., exclusion errors from the criterial recollection paradigm or repeated unrelated lures for a running recognition test). In contrast, this body of work demonstrates that matched pictures are not effective in reducing false memories when derived from extra-experimental information. Thus, internal sources of false memory may be resistant to the effect of matched picture presentation at study.

Pragmatic Inference Paradigm to Study Internally-generated False Alarms

Although matched pictures do not appear to reduce false memories for category associates, it is worthwhile to consider other related paradigms that may activate similar psychological processes. Parallels exist between generating inferences and internally-derived false alarms to related lures that have not been externally presented during the experiment.

During the pragmatic inference paradigm, when reading a pragmatic inference sentence (e.g., "*The child fell and dropped the glass cup"),* an individual may internally generate an inference (e.g., the cup *broke*), which may be subsequently incorporated into their memory and become part of their knowledge base. Thus, if on a subsequent memory test an individual were to indicate that the cup *broke*, this would be evidence of having a false memory, as they would have indicated that something occurred (i.e., cup broke), but in reality, this specific information was not externally presented. As such, pragmatic inference paradigms direct you to recall what was externally presented, and confusing your internally-generated interpretation with what you were directly exposed to, is diagnostic of rendering a false memory with this paradigm. Relatedly, when studying a series of items from a particular category (e.g., four-legged animals), high exemplar items of that category (e.g., dog) – even when not presented at study – may become internally activated at study, test, or at both time periods. Thus, generating inferences – and false alarms to related lures that have not been externally presented during the experiment – may both involve processes that result in the internal generation of an item (e.g., related lure) or an inference.

Inferences can help us to correctly interpret and understand an event or situation, but there are also times when it is important to distinguish between what was externally presented (or occurred) compared with our interpretation or inferences about the situation. For example, imagine the following scenario. An eyewitness saw two individuals run into an alley, heard a gunshot, and then saw one of the other individuals ran out of the alley. Although not directly seeing an individual shoot the gun, when being questioned by the police, the eyewitness may subconsciously infer – and report – that the person who ran out of the alley had fired the gun. Thus, inferences can help an individual better understand a situation (e.g., need to call the police due to a potential murder), but reducing reality monitoring errors by being able to differentiate one's interpretation of the event compared to what was actually presented or observed, may have critical implications in certain situations.

Effect of Imagery in the Pragmatic Inference Paradigm

Examining the literature on pragmatic inferences may point to manipulations that do reduce false memories for internally-generated information. These in turn can be applied to the categorically related false memory paradigm to determine if the same pattern of effects holds for the traditional false memory approach. By comparing manipulations that do and do not reduce these traditional false memories can in turn inform our understanding of the mechanisms involved in false memory more generally. A promising manipulation used in the pragmatic inference literature is imagery. This may be an appropriate comparison given that pictorial and imagery encoding both rely on perceptual/visual components and both paradigms (category associate and pragmatic inferences) may involve processes that result in the internal generation of an item (e.g., cup) or an action state of that item (cup breaking).

The subsequent chapter reviews the empirical findings regarding the effects of imagery on false memories and inferences and will provide a detailed rationale for comparing pictorial and imagery encoding on false memories in the category associate paradigm.

ADDRESSING THE GAPS IN THE LITERATURE

Reducing false memories for related lures requires discriminating between the item at test and the lure that may be internally-generated at study and/or test. Failure to do so may result in a reality monitoring error. As discussed previously, engaging in elaborative or effortful processing, as is likely the case with pictures presented for abstract words in the DRM paradigm, may help to improve source monitoring, and in turn, reduce source monitoring errors (Johnson, Hashtroudi & Lindsay, 1993). Viewing matched pictures at study, however, may involve minimal cognitive processing and may not be sufficient for discriminating between the item at test and the related lure. This aligns with several studies demonstrating that matched pictorial encoding is not effective in reducing false memories for related lures when using category associate paradigms (Smith & Hunt, 2020).

Reducing False Memories via Imagery Encoding

DRM Paradigm

The direction of this imagery encoding effect is mixed across different areas of research within the field of memory. In some instances, imagery encoding has been shown to increase false memories for autobiographic memories (e.g., Hyman & Pentland, 1996; Mazzoni & Memon, 2003). In contrast to this imagination inflation effect (increased false memories), generating images during encoding of DRM lists has been shown to reduce false memories (e.g., Robin & Mahe, 2015).

Foley, Wozniak and Gillum (2006) randomly assigned participants to one of three conditions, including generic-imagery, self-referential imagery, and function-only. In the generic-imagery condition, participants were asked to generate an image of the DRM word and then describe something that might be done with that object; in the self-referential imagery condition, participants were also asked to describe its function, but then generate an image that connects to them in some way of their life; lastly, in the function-only condition, they were simply asked to describe the function of the object. Their series of experiments demonstrated several notable findings. Generic-imagery decreased false memories the most, followed by self-referential imagery, with highest false memory rates occurring in the function-only group. Their follow-up experiments altered the number of items that were presented at one time during the study phase, manipulated the encoding duration, and employed the use of scripts to guide imagery. False memory rates were lower when imagery occurred for individual items (not multiple items presented at once during study), which may be a result of enhanced item-specific processing of individual items. However, even with imagery, longer encoding trials (10-sec v 5-sec) increased false memory rates, likely due to more time available for semantic activation of the critical item. Additionally, the use of guided scripts to facilitate imagery increased the rate of false memories; this may facilitate any number of generative processes (e.g., inviting the individual to co-construct the image, direct attention to previous experiences, or focus attention on hypothetical scenarios) that may engage relational processing.

Robin (2011), also using DRM lists, compared false memory rates for participants randomly assigned a generic-imagery condition or a control condition that was asked to simply memorize words. Engaging in generic-imagery resulted in fewer false memories when compared to the control condition, but this effect was only observed when using a recall test, not a recognition test (see Smith, Hunt, & Gallagher (2008) for similar boundary conditions on the modality effect for false recognition in the DRM paradigm). This effect, however, was not replicated in other work showing suggestive evidence that single imagery (i.e., imagining the content of a single word at a time) can reduce false memories for both recall and recognition (Yes/No) assessments (Oliver, Bays & Zabrucky, 2016).

This past work demonstrating that imagery reduces false memories when using DRM lists may, in part, occur from similar mechanisms through which pictorial encoding has been shown to reduce false memories when using the DRM procedure. As discussed previously, many of the DRM pictures involve abstract pictures (e.g., tongue with a spot on the tip of the tongue is assigned the word label *taste*, but this could be perceived as *tongue*, *spot*, etc.). This mismatch between the DRM picture and word label may induce elaborative processing, which in turn may create more distinct diagnostic cues to reduce the rate of false memories. The effect of the prior work on *imagery* and false memories may be influenced in a similar way. For example, trying to generate an image of abstract items, such as "sour", may require more cognitive effort and create a scenario where a potential mismatch between the visual word and mental image may aid in the rejection of critical lures by increasing the diagnostic cues of the studied items. This potential confounding effect underscores the importance that future work evaluating the effects of imagery on false memories consider using other paradigms (e.g., category associates) that employ concrete items.

Imagery and Pragmatic Inferences

The effect of imagery encoding on false memories has also been evaluated using pragmatic inference paradigms. In the only study to date on this specific topic, Maraver et al. (2021) had young adult participants read a series of pragmatic inference sentences (e.g., "*The* *karate champion hit the cinder block*”). After each sentence, participants were asked to either memorize, imagine (the content), or pay attention to the sentence. After encoding all sentences, participants engaged in a five-minute distraction task before completing a cued recall task where they were asked to fill in the sentence (e.g., “*The karate champion ______ the cinder block*”). Completing the sentence with “*broke/destroyed/crashed*”, for example, would be evidence of committing a pragmatic inference. Results demonstrated fewer pragmatic inferences in the imagine condition when compared to the other conditions.

Increasing False Memories via Imagery Encoding

In contrast to the aforementioned studies demonstrating an imagination facilitation effect (reduction in false memories), some studies have demonstrated that imagery encoding can have the opposite effect by increasing the rate of false memories (imagination inflation). Hyman and Pentland (1996) asked participants to recall events from their childhood. When they were unable to recall a specific event (reported from their parents in a previous session), they either imagined it or thought about it. On a subsequent interview with the researcher, those who previously engaged in imagery were more likely to falsely recall a childhood memory. This aligns with the previously discussed work showing that guided imagery may increase false memories (Foley et al., 2006).

In addition to the imagery of events or episodes, imagery of actions has also been shown to increase false memories. Goff and Roediger (1998) had participants listen to a series of action statements (e.g., “*tug your ear lobe*”) and then had participants either imagine the action, perform the action, or do math problems (control). Twenty-four hours later, participants returned to the lab and imagined performing the action statements 0, 1, 3, or 5 times. Two-weeks later, participants completed a recognition test. Results demonstrated that the more times an individual imagined an action statement, the higher the false alarm rate. The authors speculated that the increased frequency of imagination may have augmented the participant's familiarity with the statement and action, leading to a false memory. From a source monitoring framework, the repeated imagination sessions may increase one's perceptual vividness of the statement/action, resulting in a reality monitoring error. Other work has extended this finding by demonstrating that this effect of repeated imagery on increasing false memories also occurs for highly vivid, bizarre action statements (e.g., "*kiss the magnifying glass*") (Thomas & Loftus, 2002).

Linder and Echterhoff (2015) employed a similar action statement paradigm. Participants performed or read simple action statements, took a five-minute break, then either engaged in self-imagination or other-imagination of the action statements; self-imagination involved imaging themselves perform the action, whereas other-imagination involved imagining another person perform the desired action. Two-weeks later, participants completed a source memory test. Results showed that self-imagination, but not other-imagination, increased false memories. Thus, the visual perspective (i.e., self or other) employed during imagery may play an important role in influencing the effects of imagery encoding on false memory.

When does Imagination Decrease or Increase False Memories?

As discussed, some studies demonstrate an imagination facilitation effect, whereas other studies demonstrate an imagination inflation effect. A common theme is that an inflation effect occurs when the imagery is self-referential (highly generative process) or involves some type of procedure that may increase relational processing, such as using a guided script to facilitate imagery; imagining a "hypothetical" scenario; presenting (and then imagining) multiple items at a time at study (e.g., relational imagery), which may involve linking them together; or increasing the number of imagery sessions, which may increase perceptions of familiarity, ultimately leading to reality monitoring errors. In contrast, an imagination facilitation (decreased false memory) effect is likely to occur in situations where the imagery activates item-specific processing, such as using generic imagery or imagining a single item at a time (single imagery). Thus, imagery encoding (e.g., single imagery), similar to other ways to facilitate item-specific processing, such as familiarity ratings and pleasantness ratings, may be a useful processing strategy to accentuate item-specific features of the stimuli (Hodge & Otani, 1996). Activation of such item-specific features may reduce relational processing as well as render the diagnostic cues of the stimuli more salient, which can be used at retrieval to reject new critical items.

Pictorial and Imagery Encoding on False Memory

Our previous work demonstrates that matched picture presentation can reduce false memories when, for example, the critical item is pre-exposed at study or when it is repeatedly presented at test, ultimately evaluating false memories from external sources. However, in alignment with other work (Smith & Hunt, 2020), our laboratory's recent work shows that matched picture presentation is ineffective in reducing false memories for related lures. When using DRM or category associate paradigms, for example, the critical item may be automatically activated at study and/or at test. Elaborative, or sufficient item-specific processing, may be needed to either counteract this automatic activation of the critical item or provide enough diagnostic cues to facilitate monitoring at retrieval. Matched picture presentation at study, especially when using everyday common objects, may be insufficient in engaging elaborative processing and may have limited effects on reducing false memories for related lures. In contrast, imagery encoding may engage more elaborative, item-specific processing to reduce false memories for related lures.

To our knowledge, however, no study has directly compared the effects of matched pictorial and imagery encoding on false memories for related lures, which is the central focus of the proposed experiment. Further, and as discussed above, the prior work evaluating the effects of imagery on false memories for related lures has used a procedure (DRM lists) that involve abstract items (e.g., sour) that may create difficulty in generating a matched mental image of the item. To overcome this confound in the literature, the proposed experiment employs a category associate paradigm that involves the use of concrete items (e.g., bear, shirt, etc.) that should allow for a generated mental image to better match the visual word. Using concrete items in the present experiment will aid in our interpretation of past work on this topic to determine if the prior findings showing reductions in false memory from imagery (via DRM lists) are due to imagery/visual processing, or rather, are confounded from the enhanced elaborative processing involved in creating an image for abstract words.

Further, a direct comparison between matched picture presentation and mental imagery may shed additional insight into the role of visual processing on false memory. For example, if false memory differences do exist between imagery and perceptual processing, then this may invite explorations for whether such effects are due to potential differences in the phenomenological experience between perception v imagery; e.g., visually viewing a basketball may result in a very clear, rich, involuntary, effortless and immediate perceptual image, whereas imagining a basketball may be more delayed and require more voluntary effort. Effortful single imagery of an item may engage elaborative processing (Hodge & Otani, 1996) and may help to improve source monitoring, and in turn, reduce source monitoring errors (Johnson, Hashtroudi, and Lindsay, 1993).

Study Aims

As discussed above, matched pictures are ineffective in reducing false memories for related lures that have not been previously externally presented during the experiment. However, other types of visual processing, such imagery encoding, have been shown to reduce false memories when evaluated from paradigms where the critical item or inference is also thought to be internally activated, such as when using DRM lists or pragmatic inference sentences. It is thus conceivable that imagery encoding could reduce false memories when evaluated using a category associate paradigm. Although DRM lists have been widely used to study false memories, for this experiment, we intentionally use the category associate procedure because recent work demonstrates that many of the DRM items involve pictures that do not match their corresponding word label (Smith & Hunt, 2020). Thus, the prior work showing that imagery encoding can reduce false memories when using DRM lists may also be confounded by this potential mismatch between the mentally-generated image and the visual word. This enhanced elaborative processing from the mismatch may increase distinct diagnostic cues that can aid in the rejection of related lures. Relatedly, it is plausible that this enhanced elaborative processing could also lower hit rates given the mismatch between the visually-presented word and mentally-induced image. In partial support of this, Smith and Hunt (2020, Experiment 2) demonstrated a lower hit rate when comparing a related picture condition (e.g., hear the word "banana" but see a picture of a "monkey") to matched word and matched picture conditions. Ultimately, using a category associate procedure, as opposed to DRM lists, may help provide a more accurate depiction of the effects of visual processing on false memories for related lures.

The purpose of this proposed experiment is to evaluate the effects of different visual encoding conditions on false memory. This will be accomplished by directly comparing the effects of matched pictorial, imagery, and visual word encoding groups[6] on false memory while employing a category associate paradigm. These groups should induce varying levels of visual processing (Koenig-Robert & Pearson, 2021), allowing us to test the theoretical mechanisms through which these visual encoding groups may influence false memory. Further, as detailed below, manipulations to the test instructions will allow us to test the predictions of two key theories (impoverished relational-encoding and distinctiveness heuristic) used to explain the effects of varying levels of visual processing on false memory.

Occurring as a between-subject factor, the groups with varying levels of visual processing will include matched picture, imagery, and visual word. The matched picture group will involve viewing line drawings from a series of different categories (e.g., four-legged animals, articles of clothing); the imagery group will involve viewing the visual word and generating an image of the object depicted by the visual word; and the visual word group will involve only viewing the visual word. These three visual processing groups will be crossed with a between-subject factor of test instructions, including standard and inclusion test instructions. Standard test instructions ask participants to, for example, recall all items that were presented in the study phase. In contrast, inclusion test instructions ask participants to recall the studied items as well as other related items that matched the theme of the studied items.[7] In total, the proposed experiment will include six between-subject groups, with each of the three visual processing

[6] In the present investigation, we did not implement an auditory only group as a control group. Rather, the visual word group served as our control group. This was done because our primary goal was to compare different forms of visual processing; our approach also aligns with that of Smith and Hunt (2020) who used a visual word group as the main comparison to the matched picture condition in their third and fourth experiments.

[7] We acknowledge that, under inclusion test instructions, recalling a related item that is not part of the study list is not necessarily a *false memory*, as participants under inclusion test instructions are prompted to recall such items. However, in keeping with prior work (e.g., Hunt, Smith & Dunlap, 2011), we will use the term false recall to refer to these types of responses on both standard and inclusion tests.

groups (matched picture, imagery, and visual word) including a standard and inclusion test instruction.

The standard and inclusion tests utilized in the proposed experiment will include free recall assessments. As discussed by Hege and Dodson (2004), inclusion recall, as opposed to inclusion recognition, may be more effective at determining whether critical lures are less likely to come to mind after encoding distinctive information. For example, inclusion *recognition* of a critical lure could occur from an evoked familiarity of the item, or participants could employ a strategy at test to endorse the critical lure, regardless of the familiarity of the item (e.g., they may endorse the critical lure as an old item not because of increased familiarity but because they recognize it is related to other studied items). Additionally, not only may a recall assessment be more appropriate when determining whether critical items are less likely to come to mind after encoding distinctive information, but this will extend prior work – which has examined the effects of matched pictures on false *recognition* with a category associate paradigm (Smith & Hunt, 2020) – to determine if matched pictures and other visual encoding conditions (imagery, visual word) influence false recall. Notably, prior work using DRM lists demonstrates that visual word encoding reduces false recall, but does not always reduce false recognition (Smith, Hunt, & Gallagher, 2008).

Theoretical Predictions

As stated previously, the prevailing theories to explain the presentation modality effect include impoverished relational-encoding and the distinctiveness heuristic. These same theories can help explain the empirical findings related to imagery encoding and false memories. Briefly, the impoverished relational-encoding theory predicts that studying distinctive information increases memory for such item-specific information, but this occurs at the expense of memory for relational information. Thus, impoverished relational-encoding theory predicts that distinctive encoding increases memorial information of studied items, but related lures evoke less memorial information after distinctive encoding. In contrast, the distinctiveness heuristic predicts that studied and related lures evoke a similar level of memorial information from encoding conditions that vary on distinctiveness, but the related lure is not endorsed as an old item due to the absence of expected distinctive information (e.g., one's expectation for remembering distinctive aspects of the item) that is diagnostic for the event's nonoccurrence.

Since single imagery encoding results in item-specific processing of features of the item (Hodge & Otani, 1996) – which is thought to reduce relational processing – the impoverished relational-encoding account would predict that single imagery encoding would reduce false memories for related lures when compared to a visual word condition; prior empirical work using DRM lists supports this prediction (Foley et al., 2006). Imagery encoding may also involve more distinctive and item-specific processing when compared to a matched picture condition, and thus, this theory would also predict a lower false alarm rate for imagery encoding compared to matched pictorial encoding. If imagery encoding results in greater diagnostic cues to facilitate monitoring during retrieval, then the distinctiveness heuristic would predict that imagery encoding – relative to the visual word condition – would reduce false memories for related lures. The enhanced vividness of imagery may result in greater diagnostic cues when compared to a matched picture condition, also predicting fewer false memories for related lures for imagery encoding relative to matched pictorial encoding.

When comparing these two theories, two primary predictions occur (Hege & Dodson, 2004; Schacter et al., 2001). First, and as indicated in Table 1, the distinctiveness heuristic would predict that imagery (v matched picture and visual word) would reduce false memories under the standard test instructions, but this difference should be reduced or eliminated under inclusion test instructions; there would be no need to use the distinctiveness heuristic under inclusion instructions, as participants would report the critical items under such test instructions. In contrast, per the impoverished relational-encoding theory, imagery should enhance item-specific processing and reduce relational processing – and thus – the type of test instructions should not influence the recall rate of critical items if they do not come to mind in the first place (due to reduced relational processing).

Table 1

Summary of the predictions of the distinctiveness heuristic and impoverished-relational encoding theories on false recall.

Comparison	**Test Instructions**	**Explanation**	
		DH	**IRE**
Imagery v Word	Standard	Yes	Yes
Picture v Word	Standard	Yes	Yes
Imagery v Picture	Standard	Yes	Yes
Imagery v Word	Inclusion	No	Yes
Picture v Word	Inclusion	No	Yes
Imagery v Picture	Inclusion	No	Yes

DH = Distinctiveness heuristic theory prediction
IRE = Impoverished relational-encoding theory prediction
Yes = Prediction that false recall will be reduced in the first listed condition (e.g., imagery) compared to the second listed condition (e.g., word)
No = Prediction that false recall will not be reduced in the first listed condition (e.g., imagery) compared to the second listed condition (e.g., word)

The second prediction that discriminates between these two theories relates to recall rates for the studied items. As shown in Table 2, these two theories do not make predictions about differences in the recall rates for the studied items across conditions, but instead, makes predictions about the correct recall rate between test instructions for each condition. Per the impoverished relational-encoding theory, those in the lower item-specific processing groups (e.g., visual word) should recall more studied items under inclusion test instructions when compared to standard instructions. Under inclusion test instructions, participants may not only recollect studying the item, but may also generate the studied item from their generation of the related information (i.e., generating the critical item that shares a similar relation to the studied items). In contrast, under the standard test instructions, participants would be less likely to recall the studied item based on their memory of relational information. Further, per the impoverished relational-encoding theory, those in the higher item-specific processing groups (e.g., imagery) should have similar recall rates for studied items under both test instructions; if imagery enhances item-specific processing and reduces relational processing, then recollection of the studied items – and not generated relational information – will contribute to the recall rates for both test instructions. Thus, unlike the lower item-specific processing groups (e.g., visual word) that may have greater recall of studied items under inclusion instructions (v standard instructions) due to the generation of relational information, the suppression of relational processing in the higher item-specific processing groups (e.g., imagery) would prevent this difference from occurring, leading to similar levels of recall for studied items under the two test instructions.

Table 2

Summary of the predictions of the distinctiveness heuristic and impoverished-relational encoding theories on correct recall.

Comparison	**Condition**	**Explanation**	
		DH	**IRE**
Inclusion v Standard	Imagery	No	No
Inclusion v Standard	Picture	No	Yes

Inclusion v Standard	Word	No	Yes

DH = Distinctiveness heuristic theory prediction
IRE = Impoverished relational-encoding theory prediction
Yes = Prediction that correct recall will be higher in the first listed test instruction (i.e., inclusion) compared to the second listed test instruction (e.g., standard)
No = Prediction that correct recall will be similar in the first listed test instruction (i.e., inclusion) compared to the second listed test instruction (e.g., standard)

Hypotheses

The hypotheses are as follows. We hypothesize a main effect for group, with imagery reducing false memories for related lures when compared to the matched picture and visual word conditions. However, the matched picture and visual word groups will not differ in their false memory rates for related lures. For related lures, we hypothesize an encoding condition (imagery, matched picture, visual word) by test instructions (standard, inclusive) interaction. If in support of the distinctiveness heuristic, there should be a larger difference in the recall rates of the related lures for imagery under standard instructions when compared to inclusion instructions. For studied items, we also hypothesize an encoding condition by test instructions interaction. If in support of the impoverished relational-encoding theory, there should be no difference in the recall rates of studied items for imagery across both test instructions, but those in the other groups should have a higher recall rate for studied items under inclusion (v standard) test instructions.

Implications

This proposed dissertation has several potential implications. Prior work demonstrates that matched pictorial encoding does not reduce false memories (assessed via a recognition assessment) for related lures when compared to a visual word condition – the proposed experiment will evaluate if these findings also extend to false recall. It is possible that matched pictorial encoding may engage minimal cognitive operations (especially for common objects) and may be insufficient in facilitating item-specific processing. Research using other visual processing conditions, namely visual imagery, has been shown to reduce false memories for related lures. However, this body of work has used a paradigm (DRM lists) that has used abstract items that may create difficulty in generating a matched mental image of the item. This makes the interpretation of past work on imagery and false memory (when using DRM lists) unclear. As such, a major implication of this proposed experiment is to provide clarity on the effects of visual processing on false memory by employing multiple visual processing conditions and implementing an approach (category associates) that utilizes concrete items. Further, from an applied perspective, our findings may ultimately shed insight on the identification of different encoding strategies that individuals could select from to help reduce the generation of false memories. Finally, assuming an effect is observed, a third implication of this proposed work is the improvement in our understanding of the potential mechanisms through which visual processing may influence false memory. Understanding these mechanisms may help identify effective approaches to reduce false memories.

PILOT DATA

Before describing the proposed experiment, I will describe the methods and results for two pilot experiments, Experiments 1a and 1b. As described above, the proposed experiment will use recall rather than recognition tests. Using a recall test is thought to be a better approach to comparing standard versus inclusion test instructions. In addition, using a recall test will extend the findings of Smith and Hunt (2020), which involved only recognition tests. However, it is important to have a sufficiently high level of false recall to be able to detect any reductions that might arise from viewing pictures or engaging in imagery at study. The goal of these pilot experiments was to identify an appropriate methodological approach to observe sufficient levels of false memory to detect differences in false recall across the visual processing groups (especially between imagery and visual word) prior to implementing the proposed dissertation experiment to evaluate potential theoretical mechanisms of this expected reduction in false memory following visual imagery.

Study Design and Participants

In both experiments, participants were randomized into either imagery, matched picture, or a visual word group. Participants (Experiment 1a, M_{age} = 19.4 years, SD = 2.4; Experiment 1b, M_{age} = 18.8 years, SD = 1.8) were recruited via the Sona system from the Psychology department at the University of Mississippi and received credit towards a course research experience requirement.

In Experiment 1a, 294 participants completed the study; 26 were excluded because they took an excessive amount of time to complete the survey (> 30 minutes); 8 were excluded due to self-reported cheating; 18 were excluded because they selected "strongly disagree" or "disagree" regarding whether they put in a lot of effort during the study and test phases of the experiment; and 13 were excluded as they produced zero or just one item as a response during the test phase. After all exclusions, 229 participants were included in the analyses.

In Experiment 1b, 193 participants completed the study; 7 were excluded because they took an excessive amount of time to complete the survey (> 30 minutes); 10 were excluded due to self-reported cheating; 11 were excluded because they selected "strongly disagree" or "disagree" regarding whether they put in a lot of effort during the study and test phases of the experiment; and 5 were excluded as they produced zero or just one item during the test phase. After all exclusions, 160 participants were included in the analyses.

Materials and Equipment

All stimuli were presented, and responses collected with a program created via Qualtrics. For all studied items, at least 80% of the norming study subjects in the International Picture Naming Project (IPNP) (Szekely et al., 2004) named the picture (black and white line drawing) with the study list word. The 64 study items included eight sets of eight category exemplars used in Smith and Hunt (2020). The eight items from each of the eight study categories were presented blocked; the eight blocked categories were presented in a random order, but the items within each category were presented from highest to lowest exemplar items. The same materials and program were used in both pilot experiments (with some modifications as described below for Experiment 1b).

Procedures

All participants provided voluntary consent, with all study procedures being approved by the University of Mississippi's ethics committee prior to any data collection.

Experiment 1a. Using their own personal device, participants were instructed to pay close attention to the stimuli, as they were told that they would complete a memory task at the end of the experiment. In the study phase of Experiment 1a, participants viewed each item (middle of computer screen), one at a time, for five seconds; this period of time aligns with other studies (Foley et al., 2006) and should be of sufficient duration to form an image, as past work demonstrates that creating an image from a word can occur within 750 milliseconds (Paivio & Csapo, 1969, 1973). Further, past work demonstrates that pictures can reduce false recognition (via DRM lists) across varying presentation rates, such as three-seconds (Benmergui, McKelvie & Standing, 2017) and five-seconds (Ghetti, Qin & Goodman, 2002). For the non-picture groups, all words were presented in Calibri typeface and font size 22.

Procedures for the picture and visual word groups were similar to those of Smith and Hunt (2020). Procedures for the imagery group were similar to that of Oliver et al. (2016). Similar to other work (Foley et al., 2006; Oliver et al., 2016), the imagery group was asked to generate the mental image with their eyes open in order to avoid the confounding effect of having eyes closed for only one of the groups.

The matched **picture** group involved viewing black and white line drawings from the eight categories (e.g., four-legged animals, articles of clothing) used in Smith and Hunt (2020). The **imagery** group involved viewing the visual word and included instructions of "*After viewing the visual word, please create a mental image of the content of the word in your mind and do so with your eyes remaining open; for example, if the word is "shirt", create a mental image of this* *item (article of clothing), not the word itself.*" The **visual word** group involved only viewing the visual item.

After the 64-item study list, participants in **Experiment 1a** engaged in a five-minute[8] filler task to serve as a distraction. This filler task involved completing a series of easy arithmetic problems in which participants were asked to respond – as quickly as possible – with the correct answer (multiple choice response options). Following the five-minute filler task, participants completed a free recall test and given three minutes to complete the recall assessment.

Experiment 1b. Based on the relatively low rate of false recall of the critical items, a follow-up pilot experiment was conducted. In Experiment 1b, the same materials and methods were used, with the following changes. A two-minute retention interval (v the 5-min period used in Experiment 1a) was used and a category cued-recall test (v free recall used in Experiment 1a) was employed, which involved providing the eight category names at test and asking participants to recall as many items as possible from the study list without guessing.

Analyses

Both frequentist and Bayesian analyses were computed. For the frequentist analyses, statistical significance was established as an alpha of .05. For the Bayesian analyses, Bayes factors (BF) < .33 are interpreted as at least moderate evidence in favor of the null model, whereas BF > 3 are interpreted as at least moderate evidence in favor of the alternative model (van Doorn et al., 2021).

Results

Outcomes evaluated included the proportion of studied items recalled, proportion of critical items recalled (false recall), and the number of categories accessed. We calculated false

[8] A 5-minute filler task was used as this is the average duration when considering the Smith and Hunt (2020) 3-min filler task and the Oliver et al. (2016) 7-min filler task.

recall using two approaches. First, the 32 critical items from Smith and Hunt (2020) were used to determine the rate of false recall, which included four critical items (noted in parentheses below) from the following eight categories: four-footed animal (dog, pig, sheep, giraffe), part of human body (leg, toe, mouth, stomach), fruit (apple, pear, plumb, lemon), article of clothing (shirt, skirt, coat, sweater), type of vehicle (car, airplane, bicycle, boat), carpenter's tools (hammer, level, chisel, pliers), kitchen utensil (knife, pot, stove, mixer), and weapon (gun, club, spear, fists). Second, we also evaluated the rate of false recall when including the related critical items and all other related intrusions, where these other related intrusions were included in the category in the normative data from Battig and Montague (1969). For example, for the part of human body category, the critical items are leg, toe, mouth, stomach, while some additional related items recalled included shoulder, head, neck, and elbow. Categories accessed included the number of categories for which an item (studied or critical) was produced on the recall test; for example, if at least one item from each of four of the eight categories were recalled, the proportion of categories accessed would be .50.

Table 3 below displays the recall rate for studied and critical items across the three visual processing groups for both pilot experiments. In Experiment 1a, and with the proportion of studied items recalled as the outcome, a one-factor independent groups analysis of variance (ANOVA) demonstrated no main effect of Group, $F(2, 226) = 1.30$, $p = .28$, $\eta_p^2 = .01$, BF = .145. When using the 32 critical items from Smith and Hunt (2020), false recall did not vary as a function of Group, $F(2, 226) = 1.64$, $p = .20$, $\eta_p^2 = .01$, BF = .195. However, when considering all intrusions related to the studied categories, a main effect for Group emerged, $F(2, 226) = 3.36$, $p = .03$, $\eta_p^2 = .03$, BF = .894. A Fisher's least significant difference (LSD)-corrected post-hoc test indicated that Picture did not differ from Word, $M_{diff} = .006$, $p = .37$, BF = .244, and

Imagery did not differ from Word, M_{diff} = .011, p = .09, BF = .719, but Imagery had a lower false recall rate than Picture, M_{diff} = -.017, p = .01, BF = 3.106. Lastly, the number of categories accessed did not vary as a function of Group, $F(2, 226) = 1.67$, p = .19, η_p^2 = .01, BF = .201.

In Experiment 1b, and with the proportion of studied items recalled as the outcome, a one-factor independent groups ANOVA demonstrated no main effect of Group, $F(2, 157) = 1.02$, p = .36, η_p^2 = .01, BF = .151. When using the 32 critical items from Smith and Hunt (2020), false recall varied as a function of Group, $F(2, 157) = 2.98$, p = .05, η_p^2 = .04, BF = .809. A LSD-corrected post-hoc test indicated that Picture did not differ from Word, M_{diff} = .008, p = .34, BF = .294, or from Imagery, M_{diff} = .012, p = .18, BF = .557, but Imagery had a lower false recall rate than Word, M_{diff} = -.02, p = .02, BF = 2.854. Results were unchanged when considering all intrusions that were related to the studied categories, $F(2, 157) = 2.98$, p = .05, η_p^2 = .04, BF = .808; false recall remained lower in Imagery v Word, M_{diff} = -.02, p = .02, BF = 2.457. Lastly, the number of categories accessed did not vary as a function of Group, $F(2, 157) = 1.15$, p = .32, η_p^2 = .01, BF = .167.

Table 3

Proportion (SD) of studied and critical items recalled across the two pilot experiments.

	Sample Size	Studied Items	Critical Items [a]	All Related Intrusions [b]	Categories Accessed [c]
Experiment 1a					
Picture	79	.301 (.15)	.032 (.04)	.042 (.04)	.699 (.19)
Word	75	.266 (.14)	.028 (.03)	.036 (.04)	.650 (.19)
Imagery	74	.299 (.16)	.022 (.03)	.025 (.04)	.654 (.19)
Experiment 1b					
Picture	47	.306 (.15)	.039 (.05)	.047 (.05)	.830 (.17)
Word	58	.274 (.15)	.047 (.05)	.054 (.06)	.767 (.21)
Imagery	55	.311 (.15)	.027 (.04)	.032 (.04)	.795 (.24)

[a] Recalling a critical item occurred if they recalled any of the 32 critical items from Smith and Hunt (2020) – four from each of the eight categories – that were not part of the study list.

[b] Recalling a related intrusion item occurred if they recalled any of the 32 critical items from Smith and Hunt (2020) or recalled a non-studied item from one of the eight categories that was indexed in the normative data from Battig and Montague (1969).
[c] The proportion of categories accessed, e.g., if items (studied or non-studied, but related) from four of the eight categories were recalled, the proportion of categories accessed would be .50.

Discussion

Two pilot experiments were conducted to provide a preliminary investigation of the effects of visual processing on false recall. The first experiment demonstrated a reduction in false recall following imagery encoding. The false recall rate across the conditions was relatively low, which was the motivation for the follow-up experiment. The second experiment, which shortened the retention interval and provided the category labels at test, replicated the lower rate of false recall following imagery encoding and also elicited slightly higher false recall rates when compared to the first experiment. Bayesian analyses generally supported the frequentist analyses, in that null frequentist results were supported by at least moderate evidence in favor of the null (v alternative), and similarly, statistically significant results were supported by at least weak to moderate evidence in favor of the alternative (v null) model.

Notably, in Experiment 1b, the proportion of categories accessed was not perfect (i.e., not 100%), despite the provision of category labels at test. This, however, is similar to prior work (Hunt & Seta, 1984) demonstrating that category access is less than perfect in smaller category sizes (e.g., < 16 items per category), even when category labels are provided (e.g., during a sorting task). Furthermore, the lack of an effect of group on category access suggests that the effects of imagery is not acting through impoverished relational processing.

These pilot findings align with prior work (e.g., Oliver et al., 2016; Smith & Hunt, 2020) in that differences in visual processing did not influence the recall rate of studied items, nor was false memory different between pictorial and word encoding, but there was some evidence for reductions in false memory following imagery encoding.

Given the higher rate of false recall in Experiment 1b (v 1a), coupled with the observation of a reduction in false recall for imagery when compared to the visual word group, the proposed study will utilize the same procedures employed in Experiment 1b. As discussed previously, we will also implement two testing conditions (standard and inclusion test instructions) to evaluate the distinctiveness heuristic and impoverished relational-encoding theories as explanations for potential differential effects of visual processing on false recall.

METHODOLOGY

Study Design and Participants

A between-subject (six independent groups) randomized experimental design was employed. University of Mississippi psychology (via Sona psychology pool), health, and exercise science undergraduate students were recruited.

An a-priori power analysis (G*Power 3.1.9.2) was conducted to evaluate the sample size needed based on the design, alpha, power, and expected effect size. The assumed effect size was determined from our pilot experiments as well as from studies evaluating false memory rates when using conditions similar to the proposed experiment. Oliver et al. (2016) evaluated the effects of single-imagery and visual word on false memory (via DRM lists) and reported a main effect of, $F(1,100) = 3.46$. This F-value is equivalent to an effect size (η_p^2) of .033 (3.46*1/(3.46*1+100)); an η_p^2 of .033 is equal to a Cohen's f of .185 ($\sqrt{.033/(1-.033)}$). Smith and Hunt (2020; Experiment 2) evaluated the effects of matched picture and visual word on false memory (via category lists). Across the matched picture and visual word groups, the mean (SD) false alarm rates were .31 (.196) and .37 (.175). When comparing matched picture to visual word, $F(1,38) = 1.254$; η_p^2 of .032 (1.254*1/(1.254*1+38)); Cohen's f = .182. Schacter et al. (2001; Experiment 2) evaluated the effects of picture and visual word presentation, crossed by standard and inclusion test instructions, on false memory (via DRM lists). They reported an encoding condition by test instruction interaction of, $F(1,68) = 8.99$; η_p^2 of .117 (8.99*1/(8.99*1+68)); Cohen's f = .364. Collectively, across these experiments (Oliver et al., 2016; Schacter et al., 2001; Smith and Hunt, 2020), η_p^2 was .033, .032, and .117, corresponding to Cohen's f of .185, .182, and .364. These effect sizes also aligned with the observed effect sizes from our pilot experiments (i.e., η_p^2 of .03 to .04). Thus, when considering a 3 (*Groups*: imagery, matched picture, visual word) × 2 (*Test Instructions*: standard, inclusion) two-factor independent-groups ANOVA, 306 total participants would be needed for the following inputs, α of .05, power (1-β) of .80, six independent groups, numerator degrees of freedom of 2 (for the interaction term), and an assumed Cohen's f effect size of .18 (i.e., the most conservative effect size from above). Assuming approximately 100 participants will have unusable data (based on the pilot data), we aimed to collect data on approximately 406 participants. Data collection occurred until at least 306 participants (approximately 51 in each of the six groups) provided complete data.

In Experiment 2, 451 participants started the study; 16 were excluded as they took an excessive amount of time to complete the survey (> 30 minutes); 33 were excluded due to self-reported cheating; 46 were excluded because they indicated they "strongly disagree" or "disagree" regarding whether they put in a lot of effort during the study and test phases of the experiment; and 32 were excluded as they recalled zero or one item during the test phase. After all exclusions, 324 participants were included in the analyses.

Materials and Equipment

All stimuli were presented, and responses collected with a program created via Qualtrics. For all studied items, at least 80% of the norming study subjects in the International Picture Naming Project (IPNP) (Szekely et al., 2004) named the picture (black and white line drawing) with the study list word. The 64 study items included eight sets of eight category exemplars used in Smith and Hunt (2020). The eight items from each of the eight study categories were presented blocked; the eight blocked categories were presented in a random order, but the items within each category were presented from highest to lowest exemplar items.

Procedures

All participants provided voluntary consent, with all study procedures being approved by the authors' ethics committee prior to any data collection. After signing up for the study via Sona, participants received a link to the study and were asked to complete the study on their computer (laptop or desktop computer; program prevented completion on a phone) in a quiet place with no distractions.

Similar to our pilot experiments, participants were instructed to pay close attention to the stimuli, as they were told that they will complete a memory task at the end of the experiment. In the study phase, participants viewed each item (middle of computer screen), one at a time, for five seconds. For the non-picture groups, all words were presented in Calibri typeface and font size 22.

Procedures for the picture and visual word groups were similar to those of Smith and Hunt (2020). Procedures for the imagery group were similar to that of Oliver et al. (2016). Similar to other work (Foley et al., 2006; Oliver et al., 2016), including our pilot experiments, the imagery group was asked to generate the mental image with their eyes open in order to avoid the confounding effect of having eyes closed for only one of the groups.

The matched **picture** group involved viewing black and white line drawings from the eight categories (e.g., four-legged animals, articles of clothing) used in Smith and Hunt (2020). The **imagery** group involved viewing the visual word and included instructions of "*After viewing the visual word, please create a mental image of the content of the word in your mind and do so with your eyes remaining open; for example, if the word is "shirt", create a mental image of this* *item (article of clothing), not the word itself.*" The **visual word** group involved only viewing the visual item.

After the 64-item study list, and similar to our second pilot experiment, participants engaged in a two-minute filler task to serve as a distraction. This filler task involved completing arithmetic problems as quickly as possible.

Following the two-minute filler task, participants completed a category cued-recall test. Instead of a three-minute recall assessment – as done in the two pilot experiments – participants were allowed four minutes to complete the recall assessment given that this experiment asked them to also recall related items (if assigned to the inclusion test instructions). With category labels provided at test, and if randomized into the standard test instructions group, they were asked to type as many studied items as possible. Modeled after other work (Schacter et al., 2001; Hege and Dodson, 2004), if randomized into the inclusion test instructions group, they were asked to type as many studied items as they can recall and also any items related to the studied items that came to mind during the study phase. For those in the inclusion test instruction group, between the instructions and recall test, an attention check question was implemented, asking participants to "*Please select the option below that best describes what you were instructed to do on the word recall test.*" Options included, "*Type in words that I remembered from the study list*", "*Type in words that I remembered from the study list and any words related to the study list that came to mind during the recall test*", or "*None of the above*."

After completing the recall test, participants completed several additional items, including their degree of effort toward the task, difficulty in forming an image (if in the imagery group), and any distractions that occurred during the experiment.

Regarding effort toward the task, participants completed two items with responses ranging from 1 (strongly disagree) to 7 (strongly agree), including "*I put in a lot of effort to try and learn the words during the study phase*" and "*I put in a lot of effort during the test phase when trying to recall the words to the best of my ability*."

For those in the imagery group, and adapted from Foley et al. (2006), difficulty in forming an image was evaluated using a 5-point scale, ranging from 1 (very difficult) to 5 (very easy). Participants were asked, "*Using this scale that ranges from 1 to 5, indicate, on average, how difficult it was for you to form images of the words*."

Lastly, participants were asked, "*Were you distracted by anything while you were completing this experiment? If "yes", please indicate what the distraction was*."

Data Processing

The primary outcome of interest was the probability of recalling related lures (critical items and related intrusions) under standard and inclusion test instructions; a secondary outcome was the probability of recalling studied items under standard and inclusion test instructions.

Analyses

All analyses were conducted in SPSS (version 28). A 3 (*Groups*: imagery, matched picture, visual word) × 2 (*Test Instructions*: standard, inclusion) two-factor independent-groups ANOVA was computed. Main and interaction effects were evaluated, and if statistically significant, Sidak-adjusted post-hoc tests were employed. Statistical significance was set at $p < .05$.

REVIEW OF PREDICTIONS

Based on the pilot results, we anticipate that we will observe a main effect for group, with imagery encoding reducing false recall when compared to the matched picture and visual word groups. In contrast, we do not expect that the matched picture and visual word groups will differ in their false recall rates. To evaluate the theoretical mechanisms through which imagery encoding may reduce false memories, we will evaluate whether the results differ based on the test instructions (standard v inclusion).

The distinctiveness heuristic predicts that imagery (v matched picture and visual word) would reduce false recall under standard test instructions, but this difference should be reduced or eliminated under inclusion test instructions. In contrast, the impoverished relational-encoding theory predicts that the type of test instructions should not influence the false recall rate. Thus, if in support of the distinctiveness heuristic, we should observe an encoding condition (imagery, matched picture, visual word) by test instructions (standard, inclusive) interaction.

If imagery does continue to reduce the rate of false recall, and if there is a greater difference in the false recall rate across the visual processing conditions under standard test instructions (v inclusion test instructions), then this would suggest that the greater item-specific processing of imagery may act to reduce false recall by increasing one's metamemorial belief about what ought to be remembered. This may lead participants to enhance their monitoring at retrieval to reduce false memories.

In contrast, if imagery reduces false recall but this reduction occurs independently of the test instructions (i.e., the reduction is similar for both the standard and inclusion tests), then this would suggest that imagery encoding may act less on one's metamemorial beliefs at retrieval, but instead, reduces false recall by suppressing relational processing that would likely occur during or shortly after encoding. However, if imagery suppresses relational processing, we might have expected imagery to reduce category access in the two pilot studies, but this did not occur, suggesting that the impoverished relational processing explanation will not be supported.

RESULTS

Similar to our pilot experiments (1a and 1b), outcomes evaluated for Experiment 2 included the proportion of studied items recalled, proportion of critical items and all related intrusions recalled (false recall), and the number of categories accessed.

Table 4 below displays the recall rate for these memory outcomes across the six visual processing groups. With the proportion of studied items recalled as the outcome, a two-factor independent groups analysis of variance (ANOVA) demonstrated a main effect of Group, $F(2, 318) = 3.14$, $p = .04$, $\eta_p^2 = .02$, BF = .539, but no main effect for Test Instructions, $F(1, 318) = 1.28$, $p = .26$, $\eta_p^2 = .004$, BF = .205, and no Group by Test Instructions interaction, $F(2, 318) = .25$, $p = .78$, $\eta_p^2 = .002$, BF = .075. Regarding the main effect for Group,[9] and applying a LSD-corrected post-hoc test, those in the Picture group had a higher recall of studied items than those in the Word group, $M_{diff} = .054$, SE = .02, $p = .01$, BF = 2.329. No other post-hoc comparison were statistically significant, *p*s > .22, BFs < .317.

When using the 32 critical items from Smith and Hunt (2020), false recall did not vary as a function of Group, $F(2, 318) = 1.38$, $p = .25$, $\eta_p^2 = .01$, BF = .102, and there was no Group by Test Instructions interaction, $F(2, 318) = 2.35$, $p = .09$, $\eta_p^2 = .02$, BF = .461, but there was a main effect for Test Instructions, $F(1, 318) = 20.85$, $p < .001$, $\eta_p^2 = .06$, BF = 1233.78. Regarding the main effect for Test Instructions, those receiving Inclusion instructions had a higher false recall

[9] Due to unequal variances across groups (see Table 2), and as suggested elsewhere (Kang & Jin, 2016), main effects were evaluated with a Sidak method for confidence interval adjustment. This approach was also taken for all other significant main effects.

rate than those who received Standard instructions, M_{diff} = .036, SE = .008, p < .001, BF = 1214.56. Similar results occurred when considering all intrusions related to the studied categories; false recall did not vary as a function of Group, F(2, 318) = 1.99, p = .14, η_p^2 = .01, BF = .182, and there was no Group by Test Instructions interaction, F(2, 318) = 1.95, p = .14, η_p^2 = .01, BF = .321, but there was a main effect for Test Instructions, F(1, 318) = 22.41, p < .001, η_p^2 = .07, BF = 2464.53. Regarding the main effect for Test Instructions, Inclusion instructions had a higher false recall rate than Standard instructions, M_{diff} = .051, SE = .01, p < .001, BF = 2366.26.

Lastly, the number of categories accessed did not vary as a function of Group, F(2, 318) = .76, p = .47, η_p^2 = .01, BF = .064, Test Instructions, F(1, 318) = .21, p = .65, η_p^2 < .01, BF = .131, and there was no Group by Test Instructions interaction, F(2, 318) = 1.06, p = .35, η_p^2 = .01, BF = .149.

Table 4

Proportion (SD) of studied and critical items recalled across the six visual processing groups.

	Sample Size	Studied Items	Critical Items [a]	All Related Intrusions [b]	Categories Accessed [c]
Picture – Standard	50	.348 (.17)	.051 (.05)	.063 (.06)	.848 (.20)
Picture – Inclusion	43	.383 (.17)	.105 (.09)	.137 (.15)	.895 (.14)
Word – Standard	64	.308 (.15)	.044 (.05)	.051 (.06)	.834 (.18)
Word – Inclusion	58	.312 (.17)	.085 (.09)	.107 (.12)	.845 (.18)
Imagery – Standard	54	.325 (.15)	.056 (.06)	.064 (.07)	.870 (.19)
Imagery – Inclusion	55	.347 (.16)	.069 (.08)	.086 (.10)	.841 (.23)

[a] Recalling a critical item occurred if they recalled any of the 32 critical items from Smith and Hunt (2020) – four from each of the eight categories – that were not part of the study list.
[b] Recalling a related intrusion item occurred if they recalled any of the 32 critical items from Smith and Hunt (2020) or recalled a non-studied item from one of the eight categories that was indexed in the normative data from Battig and Montague (1969).
[c] The proportion of categories accessed, e.g., if items (studied or non-studied, but related) from four of the eight categories were recalled, the proportion of categories accessed would be .50.

Sensitivity Results

Various sensitivity analyses were computed to evaluate if the observed results were confounded by any of the additional parameters that were measured and discussed in the Methods (i.e., distraction, effort put forth during encoding and retrieval,[10] attention check, and difficulty with imagery). There was no main effect of distraction on either false memory metric and there was no two- or three-way interaction of distraction with Group or Test Instructions, all *p*s > .22. Similarly, there was no main effect of effort put forth during encoding/retrieval on false memory, or any two- or three-way interactions, all *p*s > .23. Similarly, there was no main effect of whether the attention check response in the inclusion groups was correct, or any two- or three-way interactions, all *p*s > .08. The presence of outliers[11] did not interact with either factor for any of the memory outcomes, *p*s > .07. Finally, the null effects of Group, and in particular, the lack of a reduction in false memory from imagery encoding, could be a result of participant difficulty in engaging in imagery. However, among those in the imagery groups, we did not observe a correlation between imagery difficulty and false recall for either false memory metric, *r*s < .06 and *p*s > .53.

Specific Theoretical Predictions

Table 5 shows the results of the specific theoretical predictions on false recall. From a series of two-group independent-samples t-tests, none of the theoretical predictions for standard test instructions were supported by the data. For the inclusion test, there was inconsistency in whether the theoretical predictions were supported. These results of the specific theoretical

[10] As mentioned in the Methods section, those who indicated they "strongly disagree" or "disagree" regarding whether they put in a lot of effort during the study and test phases of the experiment were excluded from all analyses. Thus, only those who indicated "neutral", "agree", or "strongly" agree were included. Thus, these sensitivity analyses were restricted to this effort variable inclusive of these three levels.

[11] Outliers were identified using the median absolute deviator (MAD) method (Leys et al., 2013) and calculated as (median ± 2.5*MAD).

predictions align with the above ANOVA results; they (Table 3) do not provide support for either theory and there was no statistically significant group × test instruction interactions from the aforementioned ANOVA analyses. The only possible exception is the weak evidence in favor of rejecting the null hypothesis in the comparisons of imagery and picture conditions in the inclusion test; but this did not meet the threshold for moderate evidence in favor of rejecting the null hypothesis.

Table 5

Summary of the predictions of the distinctiveness heuristic and impoverished-relational encoding theories on false recall and whether the data supports these predictions for Experiment 2.

Comparison	**Test Instructions**	**Explanation**		**Critical Items**	**All Intrusions**
		DH	**IRE**	***p (BF)***	***p (BF)***
Imagery v Word	Standard	Yes	Yes	.26 (.34)	.26 (.34)
Picture v Word	Standard	Yes	Yes	.52 (.24)	.25 (.36)
Imagery v Picture	Standard	Yes	Yes	.62 (.23)	.97 (.20)
Imagery v Word	Inclusion	No	Yes	.30 (.32)	.31 (.31)
Picture v Word	Inclusion	No	Yes	.25 (.38)	.27 (.36)
Imagery v Picture	Inclusion	No	Yes	.03 (1.63)	.04 (1.36)

DH = Distinctiveness heuristic theory prediction
IRE = Impoverished relational-encoding theory prediction
Yes = Prediction that false recall will be reduced in the first listed condition (e.g., imagery) compared to the second listed condition (e.g., word)
No = Prediction that false recall will not be reduced in the first listed condition (e.g., imagery) compared to the second listed condition (e.g., word)
p = *p*-value from an independent samples t-test comparing the false recall rate between the conditions.
BF = Bayes factor

Table 6 shows the results of the specific theoretical predictions on correct recall. From a series of two-group independent-samples t-tests, the data supported the distinctiveness heuristic in that there was no difference in the correct recall rate between the inclusion and standard test instructions for all of the groups. The data, in contrast, did not support the impoverished relational-encoding theory which predicts a higher correct recall rate in the inclusion test instruction (v standard test instructions) in the imagery and picture groups.

Table 6

Summary of the predictions of the distinctiveness heuristic and impoverished-relational encoding theories on correct recall and whether the data supports these predictions for Experiment 2.

Comparison	**Condition**	**Explanation**		
		DH	**IRE**	***p (BF)***
Inclusion v Standard	Imagery	No	No	.46 (.26)
Inclusion v Standard	Picture	No	Yes	.32 (.33)
Inclusion v Standard	Word	No	Yes	.89 (.19)

DH = Distinctiveness heuristic theory prediction
IRE = Impoverished relational-encoding theory prediction
Yes = Prediction that correct recall will be higher in the first listed test instruction (i.e., inclusion) compared to the second listed test instruction (e.g., standard)
No = Prediction that correct recall will be similar in the first listed test instruction (i.e., inclusion) compared to the second listed test instruction (e.g., standard)
p = *p*-value from an independent samples t-test comparing the correct recall rate between inclusion and standard instructions
BF = Bayes factor

Meta-Analyses

Experiment 2 did not observe any differential effects of visual processing on false memory. As suggested by Cumming (2014), in addition to reporting the individual experimental results, herein we meta-analyzed[12] the results from all three experiments to evaluate the global effects of visual processing on false memory. Nine forest plots were constructed, inclusive of the three memory outcomes (studied items, critical items, and all intrusions) across three group

[12] Hedges' g was calculated as the effect size (ES) and expressed as a standardized mean difference (g) between the comparative groups (e.g., picture v visual word, image v word, etc.). Effect sizes were calculated using the Comprehensive Meta-Analysis (CMA) software (v 2.0). Inverse variance weighted random-effects models were used to meta-analyze the ESs. Specifically, the "robumeta" package in RStudio was used.

comparisons (picture v word, imagery v word, and picture v imagery). In each forest plot, four effect sizes are presented, one for Experiment 1a (e.g., picture v word), one for Experiment 1b (e.g., picture v word), and two for Experiment 2 (e.g., standard picture v standard word, inclusion picture v inclusion word). The average of each of these four effect sizes in each forest plot is shown in Table 7. Across the experiments, and with recall of studied items as the outcome, those in the Picture group remembered more items than those in the Word group (ES = .26, p = .01). Similarly, Imagery had a higher recall of studied items compared to Word (ES = .21, p = .01). For critical items, those in the Picture group had a higher rate of false memory than those in the Imagery group (ES = .24, p = .02); results were similar when evaluating all related intrusions as the outcome (ES = .32, p = .04).

Table 7

Average effect sizes (Hedges' g) depicting the effect of study modality on true and false memory performance.

	Average ES	95% CI	P-value
Studied Items			
Picture v Word	.26	.11, .41	.01
Imagery v Word	.21	.11, .31	.01
Picture v Imagery	.05	-.21, .31	.49
Critical Items			
Picture v Word	.05	-.37, .47	.66
Imagery v Word	-.21	-.74, .33	.24
Picture v Imagery	.24	.09, .39	.02
All Intrusions			
Picture v Word	.08	-.34, .50	.48
Imagery v Word	-.23	-.75, .29	.19
Picture v Imagery	.32	.03, .61	.04

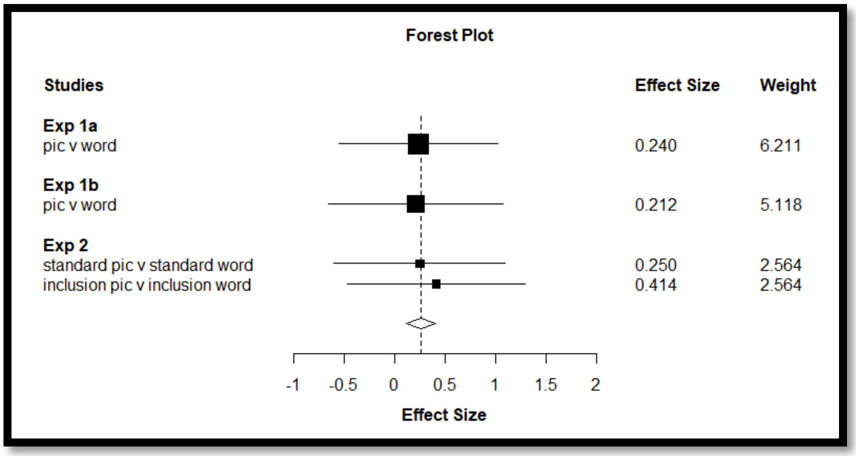

Figure 1. Forest plot depicting the Picture v Word effects on studied items.

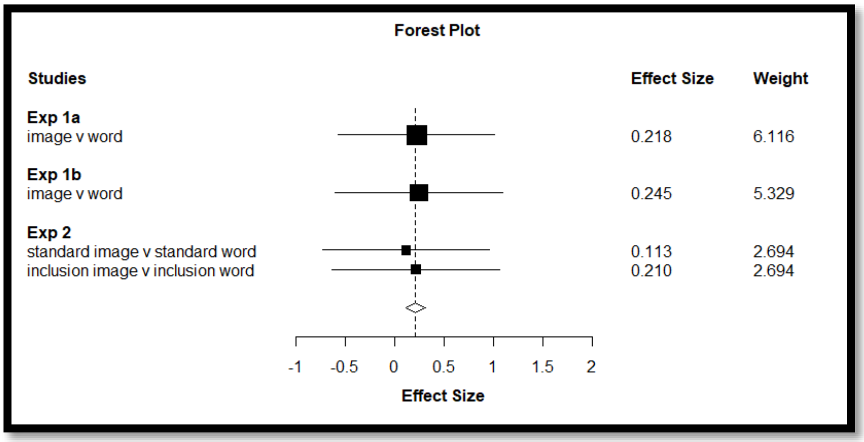

Figure 2. Forest plot depicting the Imagery v Word effects on studied items.

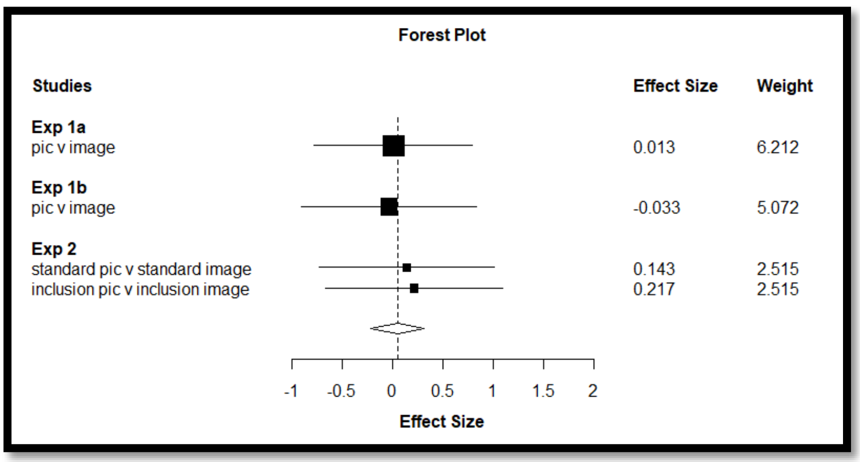

Figure 3. Forest plot depicting the Picture v Imagery effects on studied items.

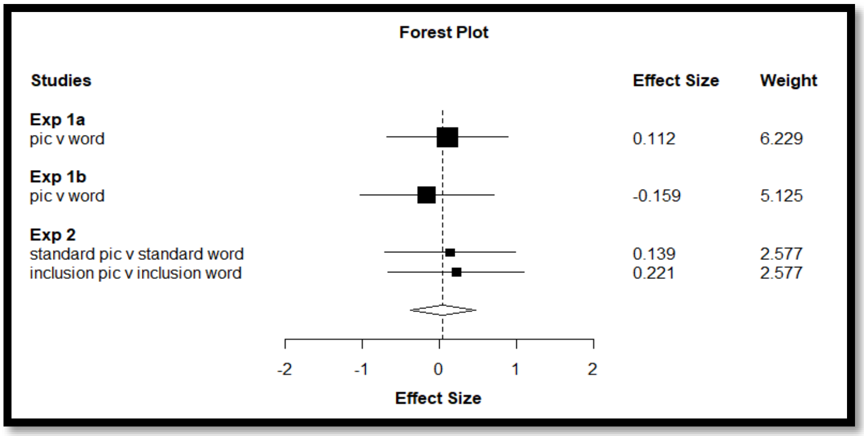

Figure 4. Forest plot depicting the Picture v Word effects on critical items.

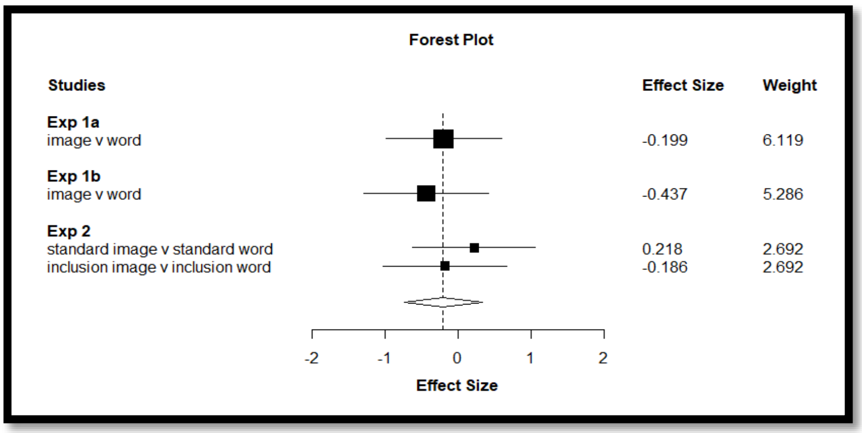

Figure 5. Forest plot depicting the Imagery v Word effects on critical items.

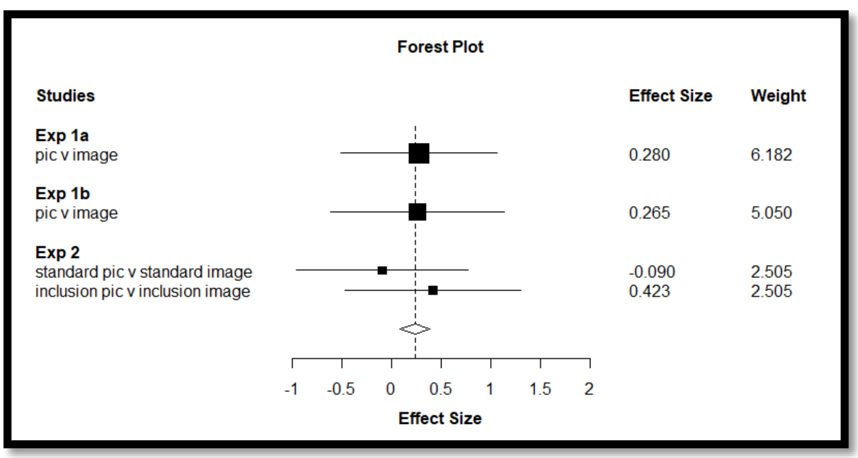

Figure 6. Forest plot depicting the Picture v Imagery effects on critical items.

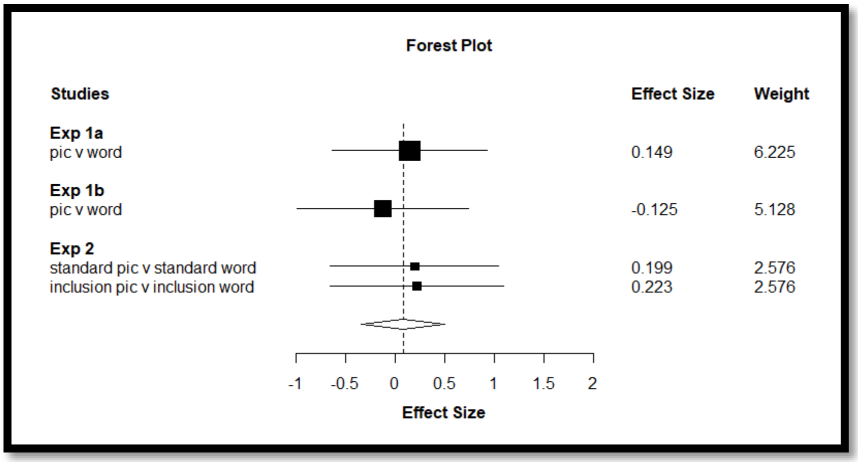

Figure 7. Forest plot depicting the Picture v Word effects on all related intrusions.

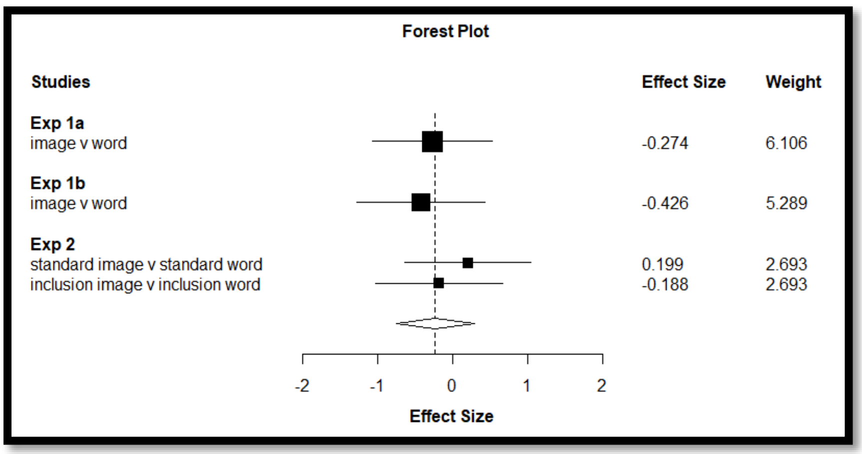

Figure 8. Forest plot depicting the Imagery v Word effects on all related intrusions.

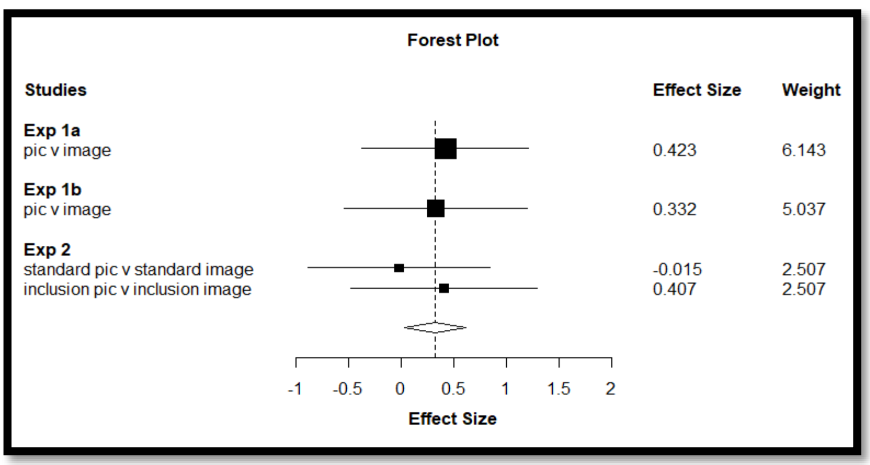

Figure 9. Forest plot depicting the Picture v Imagery effects on all related intrusions.

DISCUSSION

Overview with Main Findings

Commonly evaluated visual presentation modalities include studying items as a visual word, a picture, or viewing the visual word but engaging in mental imagery of the object represented by the word. Studies evaluating the effect of visual processing on false memories is accumulating but has produced mixed findings. Prior work has demonstrated that studying items as a picture is effective in reducing false memories, but these studies utilized *abstract* pictures that were not normed (e.g., Israel & Schacter, 1997); the observed reduction in false memory could have been due to enhanced elaborative processing of the abstract items. More recent work demonstrates that utilizing *matched* pictures that have a normative label are not effective in reducing false memory (Smith & Hunt, 2020). Other visual processing modalities, such as imagery, have been shown to reduce false memories, but again, have mostly utilized abstract items (Foley, Wozniak, & Gillum, 2006; Robin, 2011; for an exception, see Olszewska & Ulatowska, 2013).

To provide a more accurate depiction of the effects of visual processing on false memory, the present set of experiments utilized a category associate procedure where participants studied a list of concrete items either as a visual word, picture, or imagery of the item. These concrete items (e.g., cat, horse, bear) were part of a specific category (e.g., four-footed animal) – and during the testing procedure – if the participant recalled an item from a studied category – of which was not actually part of the study list (e.g., dog) – then this was evidence of false recall.

Our pilot studies (Experiments 1a and 1b) demonstrated that imagery encoding reduced false recall when compared to pictorial encoding (Experiment 1a) and visual words (Experiment 1b). Our follow-up experiment – the main study of this dissertation – re-evaluated the effect of these three visual processing conditions while also attempting to evaluate potential mechanisms of these observed effects. Manipulations to the test instructions (standard v inclusion) allowed us to test the predictions of two key theories (distinctiveness heuristic and impoverished relational-encoding) used to explain the effects of varying levels of visual processing on false memory. Under standard test instructions, participants were asked to recall items of which were part of the study list. In contrast, under inclusion test instructions, participants were asked to recall items that were part of the study list as well as any related items that came to mind.

The distinctiveness heuristic theory – which postulates that, with imagery encoding, related lures would not be endorsed as an old item due to the absence of expected distinctive information – predicts that imagery would reduce false memories under standard test instructions, but this difference would be reduced or eliminated under inclusion test instructions. In contrast, the impoverished relational-encoding theory – which postulates that imagery encoding enhances item-specific processing but suppresses relational processing – predicts that, with imagery encoding, the type of test instructions would not influence the recall rate of critical items since they would not come to mind in the first place (due to reduced relational processing).

In Experiment 2, we did not observe an effect of visual processing on false recall, with the Bayesian analyses demonstrating at least moderate evidence in favor of the null. As such, we were unable to determine whether our prior results demonstrating a lower false recall with imagery processing could be better explained by the distinctive heuristic or the impoverished relational-encoding theory. Finally, when pooling all three experiments together, our meta-analyses demonstrated that imagery encoding was effective in reducing false recall when compared to pictorial encoding.

False Memory Results of Experiment 2

The only significant false memory effect in Experiment 2 was the main effect of test instructions. Those who received inclusion test instructions had a 5.1% higher rate of false recall when compared to those receiving standard test instructions. This finding – although not surprising – demonstrates that our manipulation of test instructions was effective at what it was intended to do, i.e., increase the false recall rate by having participants recall non-presented critical items at test. Thus, our null Group × Test Instruction interaction is not likely due to an insufficient manipulation of test instructions.

Despite our pilot experiments demonstrating a reduction in false recall with imagery encoding, Experiment 2 did not demonstrate such an effect. It is difficult to explain these discrepant findings, as across the two pilot studies (Experiments 1a and 1b) and the main study (Experiment 2), the population (young college students), materials, study procedure, and format (online) were all similar. In Experiment 1b, which more closely matched Experiment 2 (2-min retention interval instead of the 5-min interval used in Experiment 1a), the picture and visual word conditions had a critical item false recall rate of 4-5%, which was the same as the picture and visual word (standard test instructions) conditions of Experiment 2. However, the main difference across the studies was that for the imagery group, the false recall rate was about 2% for the pilot experiments, compared to 5.6% for Experiment 2. It is not clear as to why Experiment 2 had a higher false recall rate for the imagery group when compared to the imagery groups in the pilot experiments. It is conceivable that, in Experiment 2, if there were several participants in the imagery group with a very high false recall rate, this may have inflated the false recall rate in that group. This, however, is an unlikely explanation of the discrepant findings across the studies, as there were no Group × Outlier interactions observed. And similarly, for Experiment 2, when excluding those with high false recall rates (outliers), the false recall rate was still similar between picture (4.7%), visual word (4.2%), and imagery (4.4%). Further, perhaps those in in the imagery group in Experiment 2 had more difficulty in engaging in imagery when compared to those in Experiment 1b. This, however, did not appear to be the case, as the mean imagery difficulty score in Experiment 2 (M = 3.09; 95% CI: 2.76-3.42) was similar to that of Experiment 1b (M = 2.98; 95% CI: 2.65-3.31). Finally, it is possible that the observed differences in the false recall rate for the imagery group across experiments may be due to expected variation in false recall with imagery encoding. In support of this, the lower bound confidence interval (3.9) of the standard imagery group in Experiment 2 (M = 5.6; 95% CI: 3.9-7.3) was somewhat similar to the upper bound confidence interval (3.6) of the imagery group in Experiment 1b (M = 2.7; 95% CI: 1.7-3.6). Thus, the higher false recall for imagery encoding in Experiment 2 (5.6%) occurred within a 95% confidence interval that was close to the confidence interval of Experiment 1b. Relatedly, the coefficient of variation (SD / Mean) for false recall in imagery was similar and high for both Experiment 1b (1.34) and Experiment 2 (1.10), demonstrating a high degree of variability of false recall with imagery encoding. This high degree of expected variability in false recall with imagery encoding is a likely explanation of the discrepant findings across the experiments.

Meta-Analytic Effects on False Memory

Our meta-analyses of the three experiments demonstrated that imagery encoding was effective in reducing false recall when compared to pictorial encoding. In Experiment 2 we attempted to evaluate potential explanations of this effect (via test instructions manipulation), but since we did not observe a differential effect of visual processing on false recall in that experiment, we are not able to determine the explanation for the lower false recall rate from imagery encoding in the pilot experiments or the results from the meta-analyses. Further work is needed to identify the explanation(s) of this effect, but as described in the Introduction section of this dissertation, it is possible that imagery encoding reduced false recall from a distinctiveness heuristic (absence of memory for expected information) and/or suppression of relational processing (impoverished relational-encoding).

Although imagery encoding had a lower rate of false recall relative to the visual word condition (Hedges' g = -.21), this effect, unexpectedly, did not reach statistical significance (p = .24). As demonstrated in Figure 5, this null effect appeared to be driven by the higher false recall rate in the imagery (v visual word) group for standard test instructions (Hedges' g = .218), as opposed to the lower false recall rate observed for imagery encoding in Experiment 1a (Hedges' g = -.199), Experiment 1b (Hedges' g = -.437), and the inclusion test instructions for Experiment 2 (Hedges' g = -.166).

Although speculative, perhaps this null effect of false recall when comparing imagery to visual word may be due to contextual issues at study and test. In the visual word group, there is contextual similarity at study and test, as items are presented in the same way across these periods. In contrast, with imagery encoding, the type processing of the items at study may not necessarily match the type of processing used at test. Per transfer appropriate processing theory (Morris, Bransford, & Franks, 1977), this mismatch in processing may be less than desirable for memory function. Relatedly, Rummer, Schweppe and Martin (2009) demonstrated that the presentation modality effect may depend on whether the study and test conditions are in congruent relation. For example, they demonstrated an attenuated study presentation modality effect of auditory study presentation with oral recall instead of written recall. Other studies have also demonstrated similar effects in that visually processing items at study may reduce false recall, but only if the items at test are presented in the same way they appeared at study (Gallo et al., 2001, Experiment 2).

Theoretical Speculations for False Recall

As stated, imagery encoding was effective in reducing false recall when compared to pictorial encoding (internal meta-analysis and Experiment 1a) and visual word encoding (Experiment 1b), but since we did not demonstrate this effect in Experiment 2, we were not able to determine whether this internal meta-analytic or pilot study effect could be explained by the distinctiveness heuristic or impoverished relational-encoding account.

As stated in the Background section of this dissertation, it is conceivable that imagery encoding could reduce false recall from both of these theoretical accounts. Per the distinctiveness heuristic theory, activation of item-specific features from imagery encoding could make the diagnostic cues of the stimuli more salient, which, at retrieval, could help the individual accurately reject new critical items; at retrieval, participants may require access to detailed visual information, and if this information is absent at test, they may reject endorsing a new, non-studied item. In support of the distinctiveness heuristic more broadly, Schacter, Cendan, Dodson, and Clifford (2001) had participants study visual words or more distinctive items (pictures) and then completed a standard or inclusion recognition test. Results demonstrated a reduction in false recognition with more distinctive encoding in the standard test, but this effect was eliminated in the inclusion test. This supports the distinctiveness heuristic account which suggests that distinctive encoding does not suppress the activation of the lure, but instead, lack of a detailed recollection of the test item would be diagnostic that the test item is new – and if given inclusion instructions, they would endorse new items (as an old item) that relate to the study items even if they lack a detailed recollection of the said item. Future work employing imagery encoding will need to be conducted to determine if similar effects occur when imagining the study items, and as noted in the introduction, the reduction in false memory seen with pictures may have more to do with the use of abstract words that are not easily conveyed in pictures – leading to elaborative processing to connect the picture and the word - rather than the pictorial information itself.

On the other hand, in support of impoverished relational-encoding, activation of such item-specific features from imagery encoding could reduce relational processing to also accurately reject new critical items. In support of this, there is some evidence demonstrating that item-specific processing can suppress relational processing. Long and Kahana (2017) had participants complete a memory task that involved studying a list of words, either with a task cue (making a judgement about the word) or no judgement task during learning. The judgement tasks involved some type of semantic processing, such as making a judgement about the size of the item (e.g., "*Does this item fit in a shoebox*?") or an animacy judgement (e.g., "*Does this word refer to something living or not living*?"). Their findings demonstrated that participants had a lower temporal contiguity of item recall (i.e., less likely to temporally cluster their recall) in the task judgement groups, suggesting that semantic – or item-specific – processing may interfere or suppress the formation of episodic or relational associations. Also in support of the impoverished relational-encoding account, Hege and Dodson (2004) had participants encode visual words or pictures and then completed either a standard or inclusion test. In support of this theory, but in contrast to that of Schacter et al. (2001), when participants were given inclusion recall instructions to report studied items as well as related items, they had a lower false recall after pictorial encoding compared to encoding visual words, suggesting that critical lures were less likely to come to mind after pictorial encoding. Again, these findings may be specific to the use of abstract words rather than the pictures themselves.

Thus, both theories (distinctiveness heuristic and impoverished relational-encoding) are conceivable explanations of our pilot and internal meta-analytic false recall results. Although our null findings from Experiment 2 preclude the ability to use the manipulation of test instruction (standard v inclusion) to explain the differences in false recall across the pilot and meta-analytic experiments, we can consider other outcomes collected in our studies to provide some speculations of which processes may be involved in the effects of visual encoding on memory. One outcome to consider is category access, defined as the number of categories (out of eight) individual items were recalled from. Across our three experiments, category access did not differ across the visual processing groups. The impoverished relational-encoding account would predict that higher levels of item-specific processing, such as from imagery encoding, should increase the rate of correct recall while concurrently suppress relational processing. If relational processing is suppressed, it would be expected that category access would decrease, as participants would be less likely to form associations across categories. It contrast to this prediction, we did not observe an effect of imagery encoding on category access, regardless of whether the category label was provided (Experiments 1b and 2) or not provided (Experiment 1a), and in all cases the Bayesian results were in favor of accepting the null hypothesis. Although these findings do not discount the role of impoverished relational-encoding on the effects of visual processing on false recall, they point to other potential explanations, which might include the distinctiveness heuristic.

Meta-Analytic Effects on Studied Items

As stated, our meta-analyses demonstrated that imagery encoding was effective in reducing false recall when compared to pictorial encoding. With correct recall of studied items as the outcome, our meta-analyses demonstrated that both pictorial and imagery encoding – relative to visual word – was effective in increasing the rate of correctly recalled items. Although prior work does not demonstrate a picture superiority effect for studied items when using a recognition test (Smith & Hunt, 2020), our finding aligns with other studies reporting a higher rate of correctly recalled items when stimuli are studied as concrete picture items relative to visual words (Amit et al., 2019). Similarly, imagery encoding has previously been shown to enhance the rate of correctly recalled concrete items when compared to a visual word group (Olszewska & Ulatowska, 2013, Experiment 2).

Collectively, our meta-analyses demonstrate that (potentially) more distinct visual encoding – either pictorially or imagery – may have unique and beneficial effects on memory performance. That is, imagery encoding reduced false recall relative to pictorial encoding, whereas imagery and pictorial encoding enhanced the rate of correctly recalled items when compared to the visual word group. Notably, the enhanced rate of correctly recalled items for imagery and pictorial encoding remained even after accounting for their false recall rate. To evaluate this, we calculated a *corrected* recall rate using the formula: correct recall rate – false recall rate. As shown in Table 8, pictorial encoding (ES = .226, $p = .003$) and imagery encoding (ES = .256, $p = .04$) had a higher corrected recall rate when compared to the visual word group. The individual forest plots depicting these results are shown in Figures 10-12.

Table 8

Average effect sizes (Hedges' g) depicting the effect of study modality on corrected recall rate.

	Average ES	95% CI	P-value

Studied Items			
Picture v Word	.226	.168, .285	.003
Imagery v Word	.256	.016, .495	.04
Picture v Imagery	-.023	-.248, .201	.69

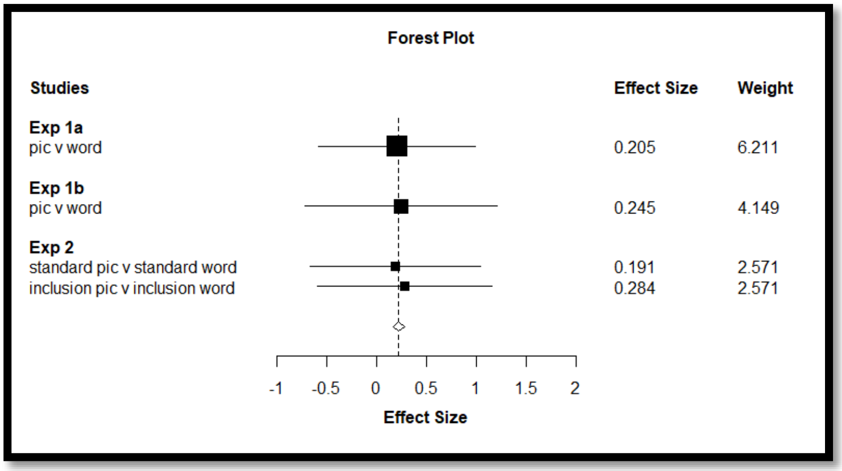

Figure 10. Forest plot depicting the Picture v Word effects on the corrected recall rate.

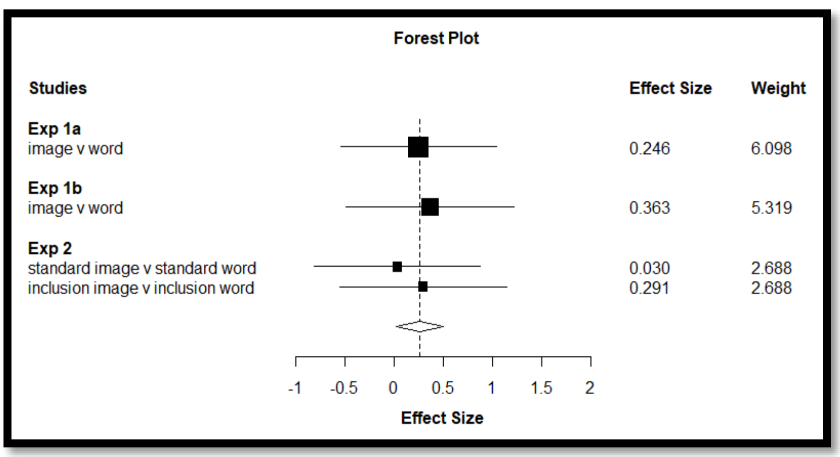

Figure 11. Forest plot depicting the Imagery v Word effects on the corrected recall rate.

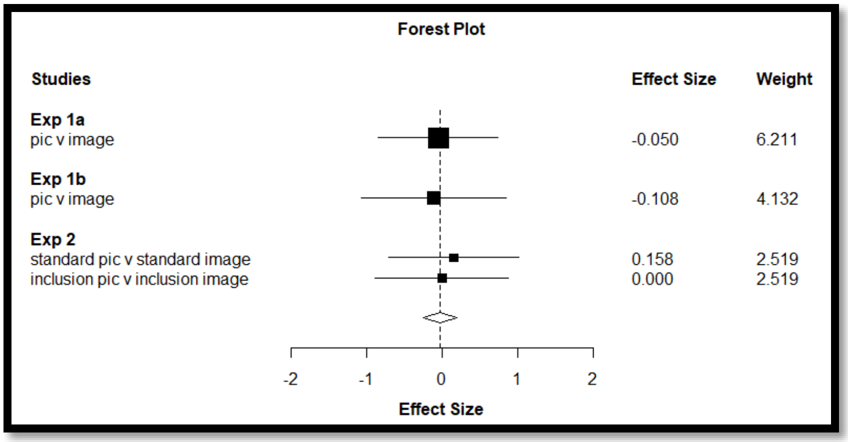

Figure 12. Forest plot depicting the Picture v Imagery effects on the corrected recall rate.

Strengths and Potential Limitations of the Current Study

Notable strengths of this dissertation include evaluating several visual processing conditions and doing so across multiple experiments. We also attempted to evaluate potential theoretical mechanisms of the effects of visual processing on true and false memory and carefully considered various factors (e.g., effort, distraction) that may influence memory performance. A limitation of this work was the inability to determine the mechanism through which imagery encoding reduced false recall in Experiments 1a and 1b. We aimed to evaluate this in Experiment 2, but since we were unable to observe an effect of visual processing on memory performance in Experiment 2, were not able to use our manipulation of test instructions to evaluate the underlying mechanisms of this potential effect.

One potential limitation in the current study is that a sufficient amount of time (e.g., 5 seconds, as done in our experiments) may be needed to elicit an imagery of the item, and such a time-matched duration in the visual word group may give these control participants enough time to utilize a specific learning strategy, of which may involve aspects of imagery, or even non-imagery strategies (rehearsal) that may lower false recall more than would be expected; this relates to past work showing that presentation duration can decrease false memory rates (McDermott & Watson, 2001). Further, even without intentionally doing so, the presentation of a visual word may spontaneously induce imagery among some participants, which may attenuate potential differences in false recall between the imagery and visual word groups, and ultimately, preclude the comparison of the distinctiveness heuristic and impoverished relational-encoding accounts. In support of this possibility, from a source memory test, Foley, Bays, Foy, and Woodfield (2015) showed that participants were more likely to indicate that they saw pictures of items that were presented as words when compared to claiming that they saw words for items presented as pictures. This suggests that participants may spontaneously experience images in response to the presentation of words. This may be more likely when using concrete words such as those used in the current study.

Difficulty in generating an image may weaken the ability to evaluate these theoretical mechanisms; imagery encoding has been shown to not reduce false recall among those classified as poor imagers (Marmurek & Hamilton, 2000). Thus, to be able to effectively evaluate these theories, it may be worthwhile to identify an optimal instruction of imagery encoding that produces a *consistent* effect on reducing false memory, if such an effect is even possible. Relatedly, it would be worthwhile to consider several practice sessions to allow participants to test their imagery ability – and if they are unable to effectively imagine the practice items – then they could either be excluded from the study or given some techniques to aid in their ability to use imagery processes.

Visual Imagery or More Elaborative Processing?

It is worth considering the variability in the specific imagery instructions used across different studies. In the present set of experiments, participants in the imagery group were given the instructions of "*After viewing the visual word, please create a mental image of the content of the word in your mind and do so with your eyes remaining open; for example, if the word is "shirt", create a mental image of this item (article of clothing), not the word itself."* This is similar but not identical to other work. For example, Olszewska and Ulatowska (2013) instructed participants to "*Read the words carefully only once, to create a vivid image of the referent of each word, and to memorize it*." McCabe et al. (2004) instructed participants to "*Think of one unique characteristic for each word that differentiated it from other words in the list*." Foley, Wozniak, and Gillum (2006) instructed participants to "*Generate an image for each object, and once the image comes fully to mind, describe something that might be done with that object*." Oliver, Bays, and Zabrucky (2016) used the approach of, "*I will present words from a list, one at a time, on the projector. As each word is presented, please create a mental image of that word in your mind*."

The variability of these imagery instructions induces varying degrees of elaborative processing – and varying degrees of item specific or distinctive processing - beyond visualizing list items that may contribute to the mixed findings in the literature. Thus, simple imagery instructions, as that employed in the present set of experiments, may induce less elaborative processing when compared to the use of generative imagery of single items. Using a more elaborative processing imagery strategy may be more robust way to enhance item-specific processing, reduce relational processing, and provide a more salient diagnostic cue to facilitate the use of a diagnostic heuristic; this may allow for a better evaluation of the distinctiveness heuristic and impoverished relational-encoding accounts to explain the potential reduction in false recall from imagery encoding. However, if the effects of imagery instructions depend on engaging more elaborative processing, this also raises questions about whether visual processing itself – either through pictures or imagery – is the key factor in reductions in false memory.

Conclusion

The present set of experiments demonstrated that viewing items pictorially may help to increase the rate of correctly recalled items. Additionally, engaging in imagery of the studied items may help to not only increase the rate of correctly recalled items, but can also have at least some limited effects in reducing the rate of falsely recalled items. Importantly, the lack of a robust effect of imagery on rates of false memory across these three studies, rather than being a weakness of the study, may instead be extending the findings of Smith & Hunt (2020) showing the reductions in false memory may be more dependent on engaging elaborative processing than on the particular pictorial information provided to participants. Future avenues for research could include investigations of whether imaging concrete words and using instructions that do not encourage additional item-specific processing, will ever show robust reductions in false memories.

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Major: Health Studies (exercise/physical activity)
Thesis: *Physiological adaptations and analysis of training content among high school cross-country runners over a season of cross-country training*
[Major Professor: Gary R. Brodowicz, PhD]

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