The Role of Visual and Verbal Processes in False Memory Susceptibility on the Misinformation Effect

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THE ROLE OF VISUAL AND VERBAL PROCESSES IN FALSE MEMORY SUSCEPTIBILITY ON THE MISINFORMATION EFFECT

by

John E. Kiat

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The role of visual and verbal processes in false memory susceptibility on the misinformation effect

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The goal of this dissertation is to investigate links between susceptibility to misinformation on the misinformation effect paradigm and individual differences in visual and verbal source monitoring ability. Results from four studies are reported. The first three studies assess links between individual differences in perceptual misinformation endorsement levels and visualization (Word-As-Picture) as well as verbalization (Picture-As-Word) errors on the memory test of a source monitoring task in which a set of objects were initially presented either as pictures or words during study. In Study 1, this picture-word source monitoring task and a misinformation effect paradigm, with a True/False test format, was administered to a sample of 87 participants. In Study 2, the same picture-word source monitoring task and the misinformation effect paradigm, this time with a two-alternative forced-choice test format, was administered to a sample of 177 participants. In Study 3, electroencephalographic (EEG) data was recorded during the testing phases of a picture-word source monitoring task and a misinformation effect paradigm administered to a sample of 19 participants. Across all three studies, verbalization (Picture-As-Word) errors was more strongly linked with misinformation susceptibility than visualization errors (Word-As-Picture). Building on these results, Study 4 assessed the misinformation susceptibility related predictive value of individual differences in visual and verbal processing during the event and narrative study stages of
the misinformation effect paradigm. In Study 4, EEG data was recorded during the during the event and narrative study phases of a misinformation effect paradigm administered to a sample of 30 participants. The primary findings from Study 4 indicate that during the event and narrative encoding stages in the misinformation effect, activity in neural regions associated with semantic and verbal processing is more strongly related to misinformation susceptibility relative to activity areas related to visual processing and encoding. Collectively, these results indicate that verbalization based processes may play a stronger role in misinformation susceptibility relative to visualization related processing. Drawing on this observation, an integrative framework highlighting the role of modality related features in a source monitoring perspective of the misinformation effect is proposed.
DEDICATION

Dedicated to the wonderful souls in my life who believed in me and gave me the faith to believe in myself
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THE ROLE OF VISUAL AND VERBAL PROCESSES IN FALSE MEMORY SUSCEPTIBILITY ON THE MISINFORMATION EFFECT

1.1 General Introduction

One of the key approaches in developing an understanding of complex systems is to study their points of failure. The study of human memory has a long tradition of utilizing this method to shed light on the processes underlying memory encoding, storage, and retrieval. Within this domain, the extensive amount of work focusing on the distortion of event (i.e., episodic) memory through external influences has led to significant advances in our understanding of the processes underlying human cognition. Indeed, some of the earliest work demonstrating that external suggestions have the potential to distort memory (e.g., Bernheim, 1884) even slightly predates the classic memory investigations of Ebbinghaus (1885), one of the first systematic investigators of human memory.

Modern research on memory distortion, however, primarily draws on pioneering work on the nature of human memory by Bartlett (1932). Today, Bartlett’s (1932) work is acknowledged as being one of the first research efforts to shed light on how human memory is often, if not always, driven by reconstructive processes; though Bartlett himself was not always unequivocal on this views on such matters (see Ost & Costall, 2002). In the most frequently cited case study from Bartlett (1932)’s qualitative work, British participants were asked to reproduce foreign folk tales – the most famous being a Canadian folktale called the War of the Ghosts – told to them first after a 15-minute delay and then repeatedly over a somewhat unsystematic manner over a period after periods of weeks, months or years. The primary finding from this being that the participants not
only became less accurate over time but also showed systematic distortions in their recollections, often integrating cultural elements from the time period into their reports (Bartlett, 1932).

Bartlett’s qualitative investigations helped to lay the foundation for the field of memory distortion, developing the framework for future quantitative research. This transition to quantitative methods began in the 1970s when, drawing on anecdotal evidence from legal practitioners on the potential biasing impact of suggestive questioning techniques on eyewitness accuracy ("Rules of Evidence for United State Courts and Magistrates," 1973) and research on the impact of question wording on participant responses (Harris, 1973), Loftus and Palmer (1974) conducted an investigation into the memory distorting impact of suggestive questioning. Loftus and Palmer (1974)’s work showed that manipulation of the action verb used in a question involving the speed of the collision of two cars in a film could increase the levels of obtained crash speed estimates as well as boost endorsements of the presence of non-existent broken glass in the film.

Building on these findings, Loftus et al. (1978) went on to show, in a series of four experiments, that inserting presuppositions into questions (e.g. implying the presence of non-existent stop sign) could lead to an increase in subsequent endorsements of the presupposed information (e.g. endorsing the presence of a stop sign). These findings led to a significant increase in the amount of research conducted on the memory distortive influences of misleading postevent misinformation (e.g. Bekerian & Bowers, 1983; Christiaansen et al., 1983; Hertel, 1982; Weinberg et al., 1983), with the phenomena often being referred to as the misinformation effect. Research on the
misinformation effect continues to be an active area of study with findings showing the effect in participants across a wide developmental range, for a wide variety of events and delivery methods as well as with different methods of misinformation presentation and memory assessment methods.

The most common form of the misinformation effect paradigm in modern psychological research proceeds as follows. Individuals view a visually presented event (i.e., the original event), receive verbal misleading post-event information (i.e., misinformation), and are subsequently tested on event details from the original event (Loftus, 1975). As a result of exposure to misinformation, participants often falsely report misleading information as having been part of the original event. These misinformation based endorsements are often accompanied by perceptual recollection reports of having seen the verbally presented misinformation (Belli et al., 1994; Mitchell & Zaragoza, 1996) comparable with, although perhaps less detailed than that of, true event memories (Schooler et al., 1986).

1.2 Theoretical Models of the Misinformation Effect

Naturally, there has long been significant interest in deconstructing the processes underlying false memory endorsements in the misinformation effect paradigm. This interest is largely driven by the potential contributions an understanding of the processes underlying the misinformation effect would make to models of episodic memory. Motivated by this potential, Wright (1995), Loftus and Hoffman (1989) and Belli (1989) identify three theoretical accounts of the misinformation effect. The first is the “destructive updating” hypothesis in which the original event memory traces are actively
impacted by exposure to post-event misinformation. The destructive memory trace alteration stance was one of the first theoretical proposals for the misinformation effect (Loftus, 1977, 1979; Loftus & Loftus, 1980; Loftus & Palmer, 1974) and comes in two forms. The strong variant argues that the original memory trace is permanently erased by the misinformation while the weaker variant argues that it is instead eroded or altered. Both variants of the updating hypothesis have been articulated by Loftus in different publications (e.g., see Loftus & Loftus, 1980 for an endorsement of the strong position) though, for the most part, it is the weaker variant (i.e., memory impairment) that Loftus most often endorses (Loftus, 1977, 1979; Loftus & Palmer, 1974).

The second proposed theoretical account is the misinformation acceptance hypothesis (Belli, 1989). This perspective argues that the misinformed participants often fail to encode the original event detail. As a result, they may often end up endorsing misinformation due to remembering it from the post-event information and not having a reason to doubt that source. This hypothesis was primarily driven by research using the modified test procedure, a two-alternative forced choice (2AFC) test in which the impact of misinformation on the access to the memory trace for event details subjected to misinformation is assessed by testing memory for these items via presenting the original and a foil detail without the misinformed detail as response options (McCloskey & Zaragoza, 1985; Zaragoza et al., 1987). Results from investigations utilizing this form of testing initially presented evidence that lent support for the misinformation acceptance hypothesis by demonstrating little to no evidence of impairment for original event memory details subjected to misinformation (McCloskey & Zaragoza, 1985; Zaragoza et al., 1987).
The third theoretical position on the misinformation effect is the coexistence hypothesis (Belli, 1989; Johnson et al., 1993; Lindsay & Johnson, 1987) in which both the original event and misleading information are proposed to co-exist in memory with the post-event misinformation benefiting from being studied more recently (Morton et al., 1985). In line with its name, the coexistence hypothesis can readily coexist alongside the misinformation acceptance hypothesis and the weaker (but not the strong) variant of the “destructive updating” hypothesis.

Apart from the strong “destructive updating” variant of the memory impairment hypothesis, the current body of research on the misinformation effect provides support for all three perspectives to some degree. There is certainly evidence that at least some false memory endorsements are driven by misinformation acceptance (Belli, 1989; van Bergen et al., 2010; Zajac et al., 2016). In support of misinformation acceptance, factors such as the level of trust participants have in their memories (van Bergen et al., 2010) and the perceived reliability of the misinformation source (Zajac et al., 2016) have both been shown to influence misinformation susceptibility. However, early work by Belli (1989) shows that misinformation acceptance alone cannot fully account for the impairment related impact of misinformation on event memory performance. Belli (1989)’s observations on this point are supported by numerous other researchers (Belli et al., 1992; Eakin et al., 2003; Schooler et al., 1988; Schreiber & Sergent, 1998), including a meta-analysis of 44 studies by Payne et al. (1994) which shows a small but significant memory impairment effect in misinformation effect experiments utilizing the modified test procedure. Thus while misinformation acceptance likely plays some role in
misinformation susceptibility, there is also evidence to support the role of memory impairment in the misinformation effect paradigm.

In addition to this body of evidence, the fact that task-related manipulations can shift responses towards event versus misinformation driven endorsements alone also provides strong evidence for the coexistence hypothesis, likely with event and misinformation based memory traces varying in encoding form and strength. The coexistence position is further strengthened by research showing that (1) priming event items via tasks involving word-primes related to them reduces misinformation susceptibility (Gordon & Shapiro, 2012) and (2) second guesses for misinformation endorsed items are more likely than chance to endorse event items (Wright et al., 1996). While few studies administer the misinformation effect paradigm with designs able to assess changes in formed memory traces for misinformation and event-based memories over time (i.e., event and narrative study phases are presented concurrently with the retention interval between both study phases and test being systematically varied), there is evidence from work by Frost and Weaver (1997) which suggests that participants draw more heavily on misinformation based memory traces over time; though the factors (i.e., encoding modality, study presentation order, etc.) driving this shift have yet to be systematically explored. Collectively, these findings converge on the idea that, over the timescale of a typical misinformation study, memory traces for both the original event and misinformation details can coexist in memory. Furthermore, while still an active area of research, modern perspectives on the neural processes underlying human memory (Johnson et al., 2009; Kitamura et al., 2017; Mitchell & Johnson, 2009) lend additional support to the coexistence perspective.
1.3 The Source Monitoring Framework and the Misinformation Effect

Given the evidence in support for the simultaneous existence of multiple, potential contradicting, memory traces, the next key theoretical issue requiring resolution is the problem of how these memory traces are retrieved, evaluated and subsequently endorsed or rejected. One of the most influential theoretical efforts in providing a foundation for assessing these questions has been the Source Monitoring Framework (SMF). The SMF builds on early theoretical work on Reality Monitoring related processes involved in making distinctions between the real and the imagined (Johnson & Raye, 1981; Johnson et al., 1977). This framework has been extended by proposing that the processes involved in Reality Monitoring are part of a more general set of mechanisms involved in forming attributions regarding the origin of mental experiences led to the development of the SMF (Johnson, 1988; Johnson et al., 1993; Mitchell & Johnson, 2000).

The SMF is grounded in Johnson (1983)’s multiple-entry modular (MEM) model of memory. In the MEM model, memory traces are proposed to arise as byproducts of the operation of numerous perceptual and reflective processes during everyday experience. Subsequently, during memory retrieval, the MEM model proposes that a subset of those perceptual and reflective processes engaged during encoding are re-evoked by retrieval cues and evaluated alongside factors such as situational expectations (e.g., being on the witness stand might increase criterion thresholds) and general knowledge (e.g., a memory of flying on a motorcycle is likely to be dismissed as being improbable).

The SMF focuses on this evaluative stage of memory processing. The framework proposes that memories are made up of a range of features including perceptual details,
semantic information, traces of cognitive operations, emotions and temporal details (Mitchell & Johnson, 2009). When a specific memory is cued or retrieved, a subset of the features that made up that particular experience is activated, alongside other situational elements such as expectations, emotional state, and task orientation (Johnson et al., 1996). Over time, the interconnections between these features are likely to weaken which may cause access to some aspects of specific memories to be lost, resulting in the degradation, but not the complete destruction, of the original memory trace (Belli et al., 1992; Johnson et al., 2009).

Central to the tenets of the SMF is the idea that the origin of remembered information is not simply tagged to our memories. Instead, the process of source attribution is the product of a complex set of heuristic and strategic decision processes made based on an individual’s assumptions regarding average differences in the features that characterize various sources and various situational factors (Gallo et al., 2006; Mitchell & Johnson, 2009). Depending on the circumstances, this attribution process is largely considered to involve varying degrees of both controlled and automatic processes (Johnson et al., 1993; Marsh et al., 1997).

Instances where these monitoring processes break down have long intrigued memory researchers who have linked source monitoring failures to a whole range of phenomena including everyday memory lapses (Brandt et al., 2014), eyewitness identification and testimony (Behrman & Richards, 2005; Memon et al., 2010), hallucinations (Larøi et al., 2004) and unconscious plagiarism (Landau & Marsh, 1997). Source monitoring paradigms have been created to investigate how we differentiate between picture and word memories (Rosburg et al., 2011a; Smith et al., 2015), internally
generated vs. heard words (Etcheverry et al., 2012; Leding, 2012; McKague et al., 2012; Simons et al., 2006), performed vs. imagined actions (Hornstein & Mulligan, 2004; Leynes & Kakadia, 2013; Lindner & Davidson, 2014; Lindner et al., 2010; Manzi & Nigro, 2008), human source characteristics (Bayen et al., 2000; Leynes et al., 2013; Sugimori & Tanno, 2010) the source of presentation fonts (Kuhlmann & Touron, 2012) and spatial locations subserves. There is also evidence to suggest that they may even play a key role in our understanding of the controversy regarding “recovered memories” of childhood sexual abuse (Belli & Loftus, 1994; Geraerts et al., 2009; McNally et al., 2005).

Of particular interest to the present dissertation, the SMF has also been frequently proposed as a theoretical model to account for how participants make memory related decisions on the misinformation effect paradigm (Dodhia & Metcalfe, 1999; Hekkanen & McEvoy, 2002; Lindsay & Johnson, 1989a; Zaragoza & Lane, 1994). From the perspective of the SMF, the misinformation effect can be naturally framed as a source monitoring problem. First, participants encode a visually presented event forming memory traces of the visually presented details. The participants then encode a verbally presented narrative, forming memory traces of the verbally presented details. Finally, with variations depending on the testing format employed, participants are asked to evaluate the veracity of presented statements or select the appropriate event item in response to questioning. During the testing stage, formed memory traces and their associated features are activated to varying degrees, providing information for source-monitoring judgments to be made regarding both an item’s accuracy and encoding source (i.e., during the visual event versus verbal narrative study stages).
To tap into this source attribution process, source monitoring focused assessments of the misinformation effect frequently utilize a source-monitoring test in which participants are asked to identify the source (i.e., the witnessed event, the post-event narrative, both or neither (indicating a guess)) of the responses they endorsed. A significant amount of research using this procedure has shown that misled participants will frequently attribute their endorsement of misinformed details to events they remember seeing during the event (Belli et al., 1994; Chambers & Zaragoza, 2001; Drivdahl & Zaragoza, 2001; Frost et al., 2002; Hekkanen & McEvoy, 2002; Lindsay, 1990; Mitchell & Zaragoza, 1996, 2001; Zaragoza & Mitchell, 1996).

This framing of the misinformation effect in the language of source monitoring highlights an intriguing point. Specifically, not only do the presentation of the event and post-event information occur at different time points, but they are also typically presented in different modalities. While the original event is typically presented visually, the misinformation narrative is almost always presented in a verbal narrative. Thus, it is likely that misinformation susceptibility may be at least partly driven by modality related source confusions (i.e., source monitoring errors associated with the misattribution of information from one modality to another). Given that visual and verbal modalities are the two information sources typically involved in the misinformation effect, researchers have focused on the relative roles of visualization and verbalization in misinformation susceptibility.
1.4 The Role of Visualization in the Misinformation Effect

Visualization has long been considered to play a key role in false-memory endorsements on the misinformation effect. This belief is likely driven by the strong evidence for the role of visualization in the formation of false autobiographical memories. Much of this belief has its roots in the “memory wars” of the 1990s (Crews, 1996). During this period there was a significant increase in cases in which individuals began to report having recovered memories of traumatic events from their childhood (Ritter, 1991). This period was characterized by a debate in which on one side were individuals who believed traumatic memories could be repressed and subsequently recovered (Blume, 1990; Freyd, 1994). On the other side were those who questioned the existence of the repressed memory phenomena and the reliability of the recovery of memories through therapy (Goldstein, 1997; Holmes, 1995; Loftus, 1993).

Of key relevance to the current discussion, this debate highlighted the potential memory distorting impact of guided visualization and other imagery based techniques (Ceci & Bruck, 1995; Goldstein, 1997; Lindsay & Read, 1994). In line with the evidence supporting that this was occurring in real-world cases at the time (Loftus, 1998; Roe & Schwartz, 1996), research work shown guided visualization is associated with increased susceptibility towards the implantation of false childhood memories (Herndon et al., 2014; Hyman & Pentland, 1996) as well as stronger shifts in the level of confidence in poorly recalled childhood memories (Paddock et al., 2000).

Likely motivated by this body of work, belief in the idea that mental imagery plays a key role in driving misinformation susceptibility has a long history in the field of memory research (Belli & Loftus, 1996; Zaragoza & Lane, 1994). The primary source of
experimental evidence for this hypothesis draws on research on the impact of perceptual elaboration on false memory. In these investigations, participants are visually presented with an event, are presented with verbal misinformation and asked to generate perceptual details involving specific items in the event or suggested items that were not present (Drivdahl & Zaragoza, 2001; Lane & Zaragoza, 2007). The general idea behind these manipulations is that they implicitly encourage the generation of visualization details of the verbally suggested events, potentially leading to increased levels of source-monitoring related difficulty. The general finding in these paradigms is that generating perceptual details for items leads to increased levels of misinformation endorsement relative to simply reading those details (Drivdahl & Zaragoza, 2001; Lane & Zaragoza, 2007).

While these results are intriguing in and of themselves, it is difficult to ascertain the degree to which they lend support to the role of visualization in the misinformation effect. As stated in the discussion section of these investigations, the generation of perceptual details impacts other cognitive processes in addition to visualization. These include deeper processing levels (Drivdahl & Zaragoza, 2001) and the engagement in more cognitive operations (Lane & Zaragoza, 2007). Of particular interest to the focus of this dissertation, encouraging the articulated generation of details may also lead to a stronger semantic and verbal traces of the presented misinformation. In support of this view, research (discussed more extensively in the next section) has shown abstract non-visual conceptual elaboration is a stronger driver of misinformation than visual elaboration (Zaragoza et al., 2011). On the whole, experimental support for the role of visualization on the misinformation effect is generally inconclusive.
There is, however, non-experimental research focused on shedding light on the role of visualization on the misinformation effect. The most direct source of evidence on this link comes from research involving the *Vividness of Visual Imagery Questionnaire* (VVIQ) (Marks, 1973). The VVIQ is a 16-item measure of individual differences in visual imagery which builds on the *Betts Questionnaire upon Mental Imagery* (Sheehan, 1967). The VVIQ verbally instructs participants to visually image specific details of specific visual scenes and record the vividness of the imagery on a five-point scale. As a measure of visual imagery, the VVIQ has been widely used in hundreds of studies to investigate the role of visualization strength across a wide range of domains (see McKelvie, 1995 for a review).

Given the widespread belief in the link between visualization strength and misinformation susceptibility, it is surprising that only a few studies have shown even weakly positive associations between the VVIQ and misinformation susceptibility. The first study in the area was conducted by Tousignant (1984) who sought to assess the link between sixteen different cognitive and personality variables and misinformation susceptibility. Tousignant (1984) found a moderate \(r = .22, p = .06\) correlation between VVIQ scores and misinformation susceptibility. While this is intriguing, it is important to note that given the 52 derived correlations in this investigation, if this effect was subjected to p-value control procedures (i.e., Bonferroni or Holms corrected), there would be a significant risk of the highlighted effect being a Type-1 error.

Also, somewhat paradoxically, Tousignant (1984) found a positive correlation \(r = .23, p < .05\) between preferences for a visual style of processing, as measured by the *visualizer-verbalizer questionnaire* (Richardson, 1977), and reduced misinformation
susceptibility as indexed by higher rates of correct item recognition on misled items. The VVQ is a self-administered 15-item questionnaire which assesses individual differences in the tendency to use mental visualization strategies versus verbalization processing strategies (Richardson, 1977; Spoltore & Smock, 1983; Stevens et al., 1986; Warren & Good, 1979). Higher scores on the inventory are indicative of a preference for verbalization over visualization. Thus the findings of Tousignant (1984) show that both a preference against using visualization (measured via the VVQ) as well as stronger levels of visualization vividness (measured via the VIVQ) are associated with increased misinformation susceptibility. Tousignant (1984) also showed the VVQ and VVIQ to be uncorrelated (r = .11) suggesting that these two constructs are largely independent and potentially draw on different underlying cognitive processes. Given these mixed, and slightly contradictory findings, Schooler and Loftus (1993) indicated a need for additional work to shed light on this issue.

The investigation which came closest to addressing this was conducted by Tomes and Katz (1997). Tomes and Katz (1997) were interested in assessing the individual difference factors predictive of habitual misinformation susceptibility or the tendency to endorse misinformation repeatedly across which utilized multiple misinformation event-study-test cycles. While Tomes and Katz (1997) did not link scores on the VVIQ and VVQ with misinformation susceptibility directly, they did correlate these measures with habitual misinformation susceptibility (i.e., the tendency to endorse misinformation in multiple events). In their results, the VVIQ showed a weak relationship (r = .15) to habitual susceptibility while the VVQ showed a nonsignificant one (r = -.04). Notably, however, akin to Tousignant (1984), no p-value control procedures were applied for the
dozen relationships investigated in Tomes and Katz (1997). Also in contrast to the significant link between habitual misinformation susceptibility and the VVIQ, Tomes and Katz (1997) found a negative relationship between two measures of mental imagery rotation ability from the Educational Testing Service Kit (Ekstrom et al., 1954) which they did not interpret. It is unclear if these opposite correlations reflect mixed findings or if the ETS results reflect content contamination from other variables such as IQ which has been shown to be negatively associated with misinformation susceptibility (Bi et al., 2010).

Notably, in a follow-up investigation of habitual susceptibility to misinformation, in contrast to Tomes and Katz (1997), Cann and Katz (2005) found a non-significant correlation between the VVIQ and habitual misinformation susceptibility. One key difference between Tomes and Katz (1997) and Cann and Katz (2005) is the presence of a source monitoring test in the latter that was absent in the former. It is tempting to speculate on how increased source monitoring stringency could potentially shift the link between visualization vividness and misinformation susceptibility. However, given that the links between habitual susceptibility and the VVIQ in Tomes and Katz (1997) and Cann and Katz (2005) are weak ($r <= .15$), coupled with unclear links between the understudied construct of habitual susceptibility and typical susceptibility on the misinformation paradigm, it is hard to draw strong conclusions on this point.

Finally, one of the main studies cited in support for the role of visualization in the misinformation effect, Dobson and Markham (1993), directly sought to link the VVIQ with misinformation susceptibility. Dobson and Markham (1993) found that participants with VVIQ scores above their sample’s median score did not exhibit overall higher levels
of misinformation endorsement (as measured by selection of misinformed items over control ones) but were less accurate (28% versus 39%) in correctly attributing peripheral additive misinformation to being only present in the narrative. It is, however, important to note that task instructions in Dobson and Markham (1993) encouraged visualization with participants being given an unrestricted amount of time to rate each narrative sentence on a 5-point scale based on the clarity of its verbal description of the visually presented 4.5-minute film. It is also interesting to note that high imagers in Dobson and Markham (1993) showed a trend towards being less accurate in attributing event items accurately to the event only (89% versus 97%, p = .13), which is intriguing given the limited sample size (n = 60) and the likelihood of a performance ceiling. Memory for the narrative was also unusually high (85%), even higher than event recollection levels (65%), with unusually high misinformation endorsement levels (58%).

On the whole, Dobson and Markham (1993)’s findings suggest that under conditions in which narrative materials are studied more extensively than the visual event under visualization-encouraging conditions, individuals with higher levels of self-reported visualization vividness on the VVIQ are more likely to misattribute additive misinformation being visually presented. While these findings are intriguing, it is important to note that the administration conditions of misinformation in Dobson and Markham (1993) differ considerably from standard misinformation presentations in most investigations of the misinformation effect. Thus the extent to which these findings carry over to typical assessments of the misinformation effect is unclear.

An additional reason to be cautious on this point comes from the fact that in contrast to the VVIQ-misinformation susceptibility links observed by Tousignant (1984),
Tomes and Katz (1997) and Dobson and Markham (1993), other investigators have often failed to find significant links between the VVIQ and misinformation susceptibility. (Cann & Katz, 2005; Desjarlais & Bernstein, 2012; Greening, 2002; Nichols, 2014; Pérez-Mata & Diges, 2007). The first of these studies is the previously mentioned investigation by Cann and Katz (2005), who found a non-significant negative correlation between the VVIQ and habitual misinformation susceptibility. The second sole published null result comes from Pérez-Mata and Diges (2007), who after failing to find a link between the two with a remember-know-guess judgment type misinformation task, disregarded the variable in all subsequent analyses.

Apart from these published studies, it is also likely that a file-drawer effect is concealing the true number of null findings in this area. Evidence in support of this comes from an assessment of unpublished research in this area by the author which uncovered three unpublished doctoral dissertations and one conference poster, all of which failed to find a significant link between the VVIQ and misinformation susceptibility. The first unpublished dissertation comes from Greening (2002), who looked at the relationship between the VVIQ and misinformation susceptibility across four independent studies, finding no correlation between the two measures in three investigations and a negative correlation between the two in one. The second unpublished dissertation by Nichols (2014) was a large (N = 373) investigation of links between the VVIQ, working memory and the misinformation effect which showed effectively no relationship (r = .06) between the VVIQ and misinformation susceptibility. The sole dissertation on the topic which found a significant correlation between the VVIQ and misinformation susceptibility was conducted by (Hegerty, 2015), who only found a weak
direct association \( r = .16 \) which was not significant after p-value control and/or after accounting factors such as working memory and test delay. Finally, an unpublished conference poster by Desjarlais and Bernstein (2012) failed to find a significant link between the VVIQ and misinformation susceptibility \( r = .05 \) in a large \( N = 151 \) sample assessment of both factors.

Thus, on the whole, the bulk of research in this area indicates that the VVIQ is not a strong predictor of misinformation susceptibility under standard misinformation study and test conditions. Even disregarding the preponderance of null findings and considering only positive results, the link between the VVIQ and misinformation susceptibility is weak at best, which is surprising given the strength of belief in the driving role of visualization in misinformation susceptibility. It is important to note, however, a key point in considering the role of VVIQ in the context of visual source monitoring. The VVIQ aims to assess individual differences in visualization vividness as opposed to measuring differences in visual source monitoring or preferences in utilizing visual imagery as an encoding strategy, the two aspects of visualization based cognition most likely to be linked to misinformation susceptibility. Thus, it is important to consider the possibility that the VVIQ may not be effective in tapping into individual differences in visual source monitoring.

In support of this point, several researchers have failed to find a link between VVIQ scores and visual source monitoring performance on measures such as the Picture-Word source monitoring task (Rosburg et al., 2011a, 2011b) and other reality monitoring paradigms (Slusher & Anderson, 1987). The Picture-Word source monitoring task, in particular, is a widely used measure of source monitoring in which participants study a
list of objects presented either as words or pictures/words+pictures (DeCarlo, 2003; Dobbins & Wagner, 2005; Hoffman, 1997; Johansson et al., 2002; Kensinger & Schacter, 2006; Stephan-Otto et al., 2017). The absence of a link between the VVIQ and this measure suggests that perhaps the VVIQ may not be a good measure of individual differences in visual memory monitoring. It is, however, important to note that prior investigations linking the VVIQ to performance on the Picture-Word source monitoring task utilize fairly small samples between 26 and 32 cases (Rosburg et al., 2011a, 2011b), leaving open the possibility that the two measures are weakly linked.

These findings indicate that (1) there is a need for a large sample investigation of the link between the VVIQ and visual source monitoring and (2) the best way to assess the role of visualization-based cognition in the misinformation effect might be to directly link misinformation susceptibility with empirically derived measures of individual differences in visual source monitoring (e.g., the Picture-Word source task).

In addition to not being associated with visual-source monitoring, the VVIQ is also uncorrelated with measures aiming to assess individual differences in preferences in utilizing visual imagery as an encoding technique. One of the most frequently utilized measures in this regard is the Verbalizer-Visualizer Questionnaire (VVQ, Richardson, 1977), a measure of individual differences in the inclination to rely on visual versus verbal mental representation preferences (Richardson, 1977; Spoltore & Smock, 1983; Stevens et al., 1986; Warren & Good, 1979). As previously discussed, Tousignant (1984), administered the VVIQ and VVQ together and showed these measures to be differentially correlated with misinformation susceptibility and uncorrelated with each other. Of particular interest, higher scores on the VVQ (indicative of a preference for verbalization-
based processing strategies over visual ones) were positively associated with misinformation suggestibility. This observation sets the stage for considering the role of verbalization in the misinformation effect.

1.5 The Role of Verbalization in the Misinformation Effect

1.5.1 Verbalization and Misinformation in Children

The discussion of the role of verbal-based processes in the misinformation effect has primarily focused on the dynamics of misinformation susceptibility in young children. Hyman et al. (1995), Hyman and Kleinknecht (1996) and Eisen, Quas, et al. (2002) have all emphasized the importance of narrative construction in false memory formation in this population. From this perspective, in addition to visualization, individual differences in the strength of narrative construction are proposed to play an important role in false memory formation. In other words, the formation of stronger and richer narratives is believed to be one of the key factors underlying misinformation susceptibility, at least among young children.

The first source of evidence in support of the role of verbal processing in the misinformation effect comes from developmental research involving young children. Roebers and Schneider (2005) examined the suggestibility of 4-year olds across multiple studies and were surprised to repeatedly observe a positive correlation between stronger language/verbal skills and misinformation susceptibility. Roebers and Schneider (2005) concluded that it was likely that having better language skills led to stronger encoding of the verbally presented misinformation, which in turn led to higher levels of misinformation endorsement. While it is tempting to note that stronger language skills are
associated with higher intelligence, a trait associated with reduced misinformation susceptibility (Bi et al., 2010), recent research on the link between cognitive functioning and false memory suggestibility in children did not find a significant link between the two in this population (Caprin et al., 2016)

Roebers and Schneider (2005) findings are consistent with prior work by Lee (2004). Lee (2004) administered a standard misinformation paradigm with a source monitoring test to a mixed sample of children (mean age = 8.5 years) and adolescents (mean age = 16.3 years) in an investigation of the interrelationships between age and various neuropsychological and social cognitive measures. These measures were comprised of the Wisconsin Card Sorting Task (a measure of task set shifting), the California Verbal Learning test (a measure of non-associative verbal memory), a backward digit span task (a measure of working memory) and the Verbal Paired Associates scale (a measure of episodic verbal association memory). The only significant association noted between these measures and misinformation susceptibility was a positive correlation between suggestibility levels and the Verbal Paired Associates scale. This result suggests that individual differences in the ability to form verbal associations in memory in young populations may be positively related to misinformation susceptibility. While intriguing, this finding should be taken with caution given its moderate strength (r = .26) and the fact that it would not have been significant after appropriate p-value control procedures.

Additional work on the link between verbal abilities and suggestibility in young children comes from two experiments from Kulkofsky and Klemfuss (2008). These studies show that while the quality of narratives generated about a specific event is
negatively associated with subsequent misinformation suggestibility on that event, general narrative ability as measured by the quality of narratives generated on non-event related memories was positively associated with suggestibility. These findings suggest that while detailed specific event memories may be resistant to suggestion, general faculty at creating event narratives is associated with increased suggestibility.

Unfortunately, as Kulkofsky and Klemfuss (2008) did not measure both types of narrative ability in the same target sample, the relative contributions of these two aspects of narrative generation remain unknown. Nonetheless, these results lend support to the idea that individual differences in processes associated with the generation of rich verbal narrative traces may be associated with increased misinformation susceptibility.

1.5.2 Verbalization and Misinformation in Adults: Experimental Work

Apart from these investigations in developmentally young populations, there has been fairly recent experimental work on the misinformation effect that lends support to the idea that non-visual verbal-based processes play a key role in driving misinformation susceptibility. For instance, Zaragoza et al. (2011) found that encouraging abstract, non-visual, conceptual reflection on presented misinformation can elevate misinformation susceptibility. Specifically, Zaragoza et al. (2011) found that reflecting on non-perceptual aspects (i.e., the meaning and implications) of event items presented in a misinformation narrative led to even greater levels of misinformation susceptibility than the visualization based perceptual elaboration methods discussed in the previous section. Of particular interest, these conceptually elaborated false memories were given perceptual source attributions, suggesting non-verbal narrative-focused processes not only play a role in
driving misinformation endorsements but can also lead to perceptual source misattributions of misinformation content.

Additional evidence for the idea that misinformation-based memories have a non-visual narrative base comes from Schooler et al. (1986). In this investigation of the qualities of false memories, Schooler et al. (1986) found that relative to true memories, verbal descriptions of misinformed memories were on average longer; contained more references to cognitive operations; more frequently referenced conceptual information such as event item functions, and contained fewer sensory details. These findings lend additional support to the idea that false memories may be drawing more heavily on verbal, narrative-focused, processes as opposed to visualization based ones.

A final study which needs to be discussed when considering experimental links between verbalization and the misinformation effect comes from research on misinformation effect narrative reading speed by Tousignant et al. (1986). In two separate studies, Tousignant et al. (1986) found that participants who (1) naturally read more slowly or (2) who were instructed to read more slowly, were both more likely to detect discrepancies on the misinformation effect and were less susceptible to misinformation. To interpret these findings, it is important to distinguish between natural and instructed reading speed.

From this perspective, results regarding natural reading rate differences suggest that participants who either (1) read more slowly naturally or (2) detected discrepancies in the narrative and subsequently slowed down, were less susceptible to misinformation. Slower readers may have encoded the narrative less effectively or, given the possibility that they were less adept with verbal processing than fast readers, may have been less
likely to draw on their memory for the verbally presented material. It is also possible that discrepancy detection induces a slowdown in reading speed, causing participants to scrutinize the material more carefully. The difficulty in disentangling natural reading speed from induced changes in discrepancy detection makes it difficult to draw firm conclusions on this point. It is possible that both factors contribute to the observed findings in Tousignant et al. (1986). It would be interesting to model possible changes in reading rates over time from pre to post-discrepancy presentation to shed some light on this issue.

With regard to the instructed reading condition, it is clear that being instructed to read a narrative slowly results in reduced misinformation susceptibility driven by increased discrepancy detection. Tousignant et al. (1986)’s findings are fairly clear in that regard. It is, however, difficult to disentangle preferences for verbal representations and discrepancy detection under these conditions. This difficulty is elevated by the fact that despite the cover instructions indicating that the purpose of the reading task was to evaluate writing style, being instructed to read slowly is largely equivalent to being instructed to read carefully. Reading in this manner would result in both a strongly encoded verbal trace for the narrative information while simultaneously boosting levels of discrepancy detection. Given the use of a single-critical item, it is impossible to disentangle the relative contribution of these two factors. Indeed, in their discussion of these results, Tousignant et al. (1986) explicitly state their belief that the link between the amount of attention allocated to the misinformation narrative and misinformation susceptibility is curvilinear. Specifically, Tousignant et al. (1986) argue that the highest level of misinformation susceptibility would be noted when sufficient attention towards
encoding the misinformation is allocated, but not so much that the discrepancies are detected.

This detailed consideration of Tousignant et al. (1986) raises several important points regarding the assessment of the link between individual differences in the strength of, or preference for, verbal representations and misinformation susceptibility. First, the presentation of visual event and misinformation narrative items should be standardized to be at a fixed rate to control the amount of time participants allocate to each event. This control would also ensure an equal amount of time for discrepancy detection and encoding across participants. Second, a sufficient number of critical items must be presented to ensure a sufficiently robust measurement of misinformation susceptibility. Indeed, the second point has become standard practice in current research involving the misinformation effect, all of which utilize paradigms with multiple pieces of misinformation. Intriguingly, this methodological shift may be driving a shift in what the misinformation effect is measuring. It is likely that performance on single-item misinformation effect paradigms draws more heavily on discrepancy detection related processes while multi-item misinformation effect paradigms more strongly reflect source monitoring related factors. To the best of my knowledge, this possibility has however not yet been assessed, leaving it as an interesting question for future research.

1.5.3 Verbalization and Misinformation in Adults: Non-experimental Work

Apart from the experimental work discussed in the previous section, the link between verbal abilities and misinformation susceptibility in adult populations using correlational approaches has not been extensively explored. One of the few studies on
this topic was a large-sample investigation of the role of cognitive factors in the misinformation effect which failed to find a link between verbal intelligence and misinformation susceptibility (Zhu, Chen, Loftus, Lin, He, Chen, Li, Xue, et al., 2010). It is important to note, however, that verbal intelligence is a broad construct which lacks the specificity to draw strong conclusions regarding the role of verbalization processes in the misinformation effect. This point is especially important to consider given research findings which show a negative relationship between intelligence quotient (IQ) levels, a measure to which verbal intelligence strongly contributes to, in adults and misinformation susceptibility (Gudjonsson, 1983; Zhu, Chen, Loftus, Lin, He, Chen, Li, Xue, et al., 2010).

Another non-experimental line of research which has potential to shed light on the link between verbal processing and the misinformation effect comes from work involving the Verbalizer-Visualizer Questionnaire (VVQ, Richardson, 1977), the previously discussed measure of individual differences in the inclination to rely on verbal versus visual codes (i.e. linguistic or imagery based representations) in everyday cognition. As mentioned earlier, a positive link between the VVQ and misinformation susceptibility was noted by Tousignant (1984). This result, referred to by Schooler and Loftus (1993) as “paradoxical”, makes sense if verbal processes play a stronger role in misinformation susceptibility than previously suspected.

Possibly due to the absence of a theoretical model of the misinformation paradigm which emphasizes the role of verbalization, this intriguing potential link between the VVQ and the misinformation effect has not received significant attention. This gap is unfortunate given neuroimaging work by Kraemer et al. (2009) which shows that
verbalization ratings on the scale are significantly correlated with activity in regions associated with phonological processing (supramarginal gyrus: Deschamps et al., 2014; Paulesu et al., 1993) during picture processing. These findings not only provide validity support for the VVQ but also present a potential mechanism for how the encoding of visual materials can be driven by non-visual encoding processes. In conjunction with the previously discussed findings of Zaragoza et al. (2011), Kraemer et al. (2009)’s results support the idea that attributions to a visual source can potentially be driven by non-visual processing.

Additional indirect support for the role of verbalization in the misinformation effect utilizing the VVQ comes from Tomes and Katz (1997) who found a preference for verbal representation to be associated with a poorer confidence-accuracy relationship on misinformation item responses and Nori et al. (2014) who found that a preference for verbal representation to be associated with reduced recollection of accurate event memory details during cognitive interviewing. On the whole, however, measures of verbalization tendencies such as the VVQ are rarely present in investigations of individual differences in misinformation susceptibility as compared to measures of visualization preferences and ability which continue to be used despite repeated null findings (e.g. Cann & Katz, 2005; Desjarlais & Bernstein, 2012; Greening, 2002).

1.6 Neuroimaging of Visual\Verbal Processes in the Misinformation Effect

To shed further light on the level of support for the respective roles of verbalization and visualization in the misinformation effect, this section discusses the neuroimaging-based sources of evidence involving both modalities. The advent of
neuroimaging-based methods over the past few decades has equipped researchers with valuable tools by which to shed light on previously inaccessible aspects of human cognition. With these methods in hand, three investigations have sought to shed light on the neural processes underlying the misinformation effect: Okado and Stark (2005), Stark et al. (2010) and Baym and Gonsalves (2010). Both Okado and Stark (2005) and Baym and Gonsalves (2010) focused on assessing encoding-related activity on the paradigm while Stark et al. (2010) focused on the retrieval stage. These investigations have the potential to provide valuable information on the relative roles of visualization and verbalization in the misinformation effect. If visualization plays a dominant role, one would expect to see misinformation susceptibility to be associated with the level of activity in neural regions associated with visualization such as in the low level visual areas V1 and V2 (Cui et al., 2007; Naselaris et al., 2015) or high level visual areas associated with place and scene imagery and processing as the parahippocampal place area or transverse occipital sulcus (Aguirre et al., 1998; Cichy et al., 2012; Epstein & Kanwisher, 1998; Hasson et al., 2003; O’Craven & Kanwisher, 2000). On the other hand, if non-visual verbalization processes play stronger role, one might expect to see activation in areas associated with verbal processing such as the supramarginal gyrus (Deschamps et al., 2014; Paulesu et al., 1993), superior temporal (Buchsbaum et al., 2001; Chan et al., 2014; Leff et al., 2009; Moseley et al., 2014) and left inferior frontal regions (Keller et al., 2009; Newman et al., 2003; Novick et al., 2009).

The first investigation providing information on these hypotheses comes from the first fMRI study of the misinformation effect by Okado and Stark (2005). Specifically, Okado and Stark (2005) investigated encoding activity during both the original event and
misinformation phases using a slightly unorthodox paradigm in which both the event and misinformation were presented visually. Okado and Stark (2005) found that activity in the same neural regions (the left hippocampus tail and the perirhinal cortex) was associated with the encoding of both true event memories and false misinformation-based details. Critically, however, no differences in activity in visualization related regions between misinformation endorsements and rejections during encoding were noted in Okado and Stark (2005). Their results suggest that the strength of visualization-based processing of misinformation content during encoding was not strongly associated with subsequent misinformation endorsement.

It is possible that visualization focused differences in the encoding of information leading to misinformation endorsements versus rejections in Okado and Stark (2005) were absent due to the fact that misinformation in Okado and Stark (2005)’s design was presented visually. This visual presentation could have reduced the need for and, and thus the role of, visualization in misinformation susceptibility. However, work by Baym and Gonsalves (2010) indicates that this variation in procedure does not account for the observed absence of visualization associated activity. Using a more traditional verbally presented misinformation narrative, Baym and Gonsalves (2010) to their surprise, failed to find evidence to support their prediction that, relative to rejected misinformation details, the encoding of misinformation details later endorsed as true memories would be associated with greater levels of neural activation in regions associated with visual imagery. Instead, they found evidence of increased activity in BA45, a neural region associated with semantic processing (Keller et al., 2009; Newman et al., 2003; Novick et al., 2009), verbal retrieval (Heim et al., 2009) and the cognitive control of memory
(Badre & Wagner, 2007a), during the encoding of visual events on which participants were subsequently susceptible to misinformation. Baym & Gonsalves also found directional evidence of activity in this region being significantly higher in both true and false memories relative to foil endorsements. In summary, in line with the findings of Okado and Stark (2005), Baym and Gonsalves (2010) did not find differences in neural activity associated with visualization between endorsed misinformation versus rejected misinformation and instead found more evidence for the role of non-visual processes.

Considering Okado & Stark (2005) and Baym and Gonsalves (2010) in isolation does not rule out the possibility that the influence of visualization on the misinformation effect presents itself during the testing stage. To address this issue, Stark et al. (2010) investigated neural activity during the retrieval stage of the misinformation effect after participants were exposed to verbal misinformation presented auditorily. While true memories were associated with activity in visual regions (BA 17 & 18: see Fulford et al., 2017), misinformation-based false memories were associated with activity in regions associated more strongly with auditory and language processing (BA22 & 42: see Buchsbaum et al., 2001; Chan et al., 2014; Leff et al., 2009; Moseley et al., 2014). In summary, prior neuroimaging based investigations into the misinformation effect have consistently failed to find evidence of neural activity associated with visualization in false memory encoding or endorsements. Instead, these studies have generally found more evidence for the role of semantic and verbal processes.
1.7 Summary of Visual\Verbal Processing in the Misinformation Effect

Taken as a whole, the evidence for the role of visualization in the misinformation effect is surprisingly tenuous. On typical administrations of the misinformation effect paradigm, there is limited evidence to support the idea that visualization is the primary driver behind the formation of false misinformation-based memories and endorsements. In some sense, these findings may not be overly surprising. From the perspective of the source monitoring framework, the misinformation effect paradigm can be conceptualized as source monitoring problem involving temporal and modality related differences. Typically, the original event is presented first, typically in a visual form (though some variants of the task involve auditory information) whereas the misinformation is presented second in verbal form, either in writing or auditorily. It is possible that instead of being primarily driven by visualization based source confusions, misinformation susceptibility may instead be most strongly related to an overreliance on verbal, narrative-focused, representations.

1.8 Dissertation Goals

The collective evidence for the role of verbal process in the misinformation effect raises an intriguing proposal. If participants focus on forming verbal narratives of the event during its visual presentation, this preference for narrative representation could set the stage for heightened levels of source confusion. This difficulty would arise from the elevated challenge of differentiating between similar as opposed to dissimilar source modalities (Henkel et al., 2000; Johnson et al., 1993; Thierry & Pipe, 2009). A similar effect could also arise if misinformation susceptibility is associated with a preference for
the verbal representation in the misinformation effect during the retrieval stage. Indeed, it is possible that both effects underlie the misinformation effect, with the focus on forming verbal narratives during event presentation being linked with preferential reliance on the verbally presented misinformation narrative.

This dissertation aims to assess the evidence for these intriguing possibilities using a multimethod approach. The overall goal of this dissertation is to investigate the links between the misinformation effect and visualization\verb|\|verbalization source monitoring related processes. The structure of this dissertation proceeds as follows. First, two behavioral studies (Studies 1 and 2) are presented in which links between misinformation susceptibility and individual differences in visual and verbal source monitoring misattribution errors are assessed. The first of these studies utilizes a true\verb|\|false memory test while the second utilizes the 2AFC test. Study 3 presents an event-related potential (ERP) focused investigation in which neural components of recollective strength from a picture-word source monitoring task and the misinformation effect are linked. Specifically, links between the recollective strength of misinformation endorsements and verbal as well as visual source memory endorsements are assessed in Study 3. Finally, Study 4 presents a source frequency based investigation of encoding activity on the misinformation effect paradigm. The aim of Study 4 is to assess the relative level of evidence for the role of visual versus verbal processes in driving encoding differences linked with higher levels of misinformation susceptibility. Finally, the collective implications and future directions of these studies are discussed. The specific aims of this study are listed below.
Specific Aim 1: To contrast differences in the strength of the association between misinformation susceptibility and basic visual as well as verbal source monitoring errors.

Specific Aim 2: To test the robustness and replicability of detected relationships between misinformation susceptibility and basic visual as well as verbal source monitoring errors.

Specific Aim 3: To investigate potential links between neural activity associated with recollective processing in misinformation endorsements and basic visual as well as verbal source monitoring errors.

Specific Aim 4: To investigate potential links between neural activity associated with event and narrative encoding on the misinformation effect and misinformation susceptibility.

Study 1: Introduction

Study 1 aims to meet Specific Aim 1 (i.e., to contrast differences in the strength of the association between misinformation susceptibility and basic visual as well as verbal source monitoring errors). Thus, the goal of Study 1 is to assess the behavioral links between individual differences in misinformation susceptibility and visualization as well as verbalization based source monitoring misattribution errors. To achieve this aim, a misinformation effect task and a picture-word source monitoring paradigm were administered to a sample of undergraduate research participants.

In the misinformation effect task, participants viewed several visually presented events followed by a narrative containing misinformation. During the testing phase, to obtain as measures of memory strength for the original and misleading information which were as independent as possible, a true/false test format with a source monitoring component was administered. In this test, participants were presented with a statement
that either accurately described the original event (assessment of original memory strength) or inaccurately described the event but accurately described the misinformation. After rating each statement, participants were then asked to indicate if they made their response based on something they remember from the event (“seen”), the text (“read”), both the event and text (“both”) or if they were guessing (“neither”). The primary measure of interest in Study 1 is misinformation statements given perceptual endorsements (i.e., “seen” or “seen and read”). By using a true/false test primarily targeting recognition of misleading event information, this investigation sought to obtain as clean a measurement of perceptual misinformation endorsement as possible. The use of a true/false test provides a measurement minimally impacted by the intentional cueing of the original event item trace, which is more likely to occur using the 2AFC testing format (which is utilized in Study 2).

The source monitoring task used was a picture-word source monitoring task (DeCarlo, 2003; Dobbins & Wagner, 2005; Hoffman, 1997; Johansson et al., 2002; Kensinger & Schacter, 2006; Rosburg et al., 2013; Rosburg et al., 2011a, 2011b; Stephan-Otto et al., 2017) in which participants were presented with a set of pictures and words under specific task instructions (see methods section for full details). After the study phase, participants were tested for their memory for items using an old-presented-as-picture, old-presented-as-word or new source monitoring test. The primary measures of interest in this specific task were individual differences in the number of errors attributing verbally presented items as having been presented as pictures (i.e., Word-As-Picture visualization errors) as well as differences in the number of attributions of visually presented items as having been presented as words (i.e., Picture-As-Word
verbalization errors). Drawing on the limited evidence for the role of visualization on the misinformation effect and stronger evidence for the role of verbalization, the primary hypothesis of Study 1 was that Picture-As-Word error rates would be more strongly predictive of misinformation susceptibility than Word-As-Picture errors. In addition to these primary goals, two inventories were administered in this investigation, the Marlow Social Desirability Questionnaire, and the Dissociative Experiences Questionnaire.

The Dissociative Experiences Questionnaire (DES) assesses individual differences in the tendency to experience dissociative experiences (e.g., mind wandering while driving, not recognizing oneself in the mirror) in everyday life. Links between the DES and misinformation susceptibility are frequently investigated in many studies of the misinformation effect. Much of this interest is driven by the previously discussed “memory wars” debate on the role of suggestive therapy on real-world false memory formation (Ceci & Bruck, 1995; Goldstein, 1997; Lindsay & Read, 1994). Dissociative tendencies have shown strong links to hypnotizability, and thus many researchers have sought to link this measure to misinformation susceptibility. Findings on this have however been mixed with some researchers showing significant links (Hekkanen & McEvoy, 2002; Merckelbach et al., 2000) and others finding no significant associations (Drivdahl & Zaragoza, 2001; Eisen, Morgan, et al., 2002; Monds et al., 2013; Otgaar et al., 2017; Zhu, Chen, Loftus, Lin, He, Chen, Li, Moyzis, et al., 2010).

The goals of administering the DES in this study is to (1) assess the direct link between this measure and misinformation susceptibility in this investigation’s specific target population and (2) assess the measure’s potential moderating role with regard to the link between misinformation susceptibility and visualization as well as verbalization
source monitoring errors. There are theoretical reasons to suspect that even if a link between misinformation susceptibility and visualization may not be present in typical populations, such a link may be present among individuals with high levels of dissociative tendencies (Danielle & Robert, 2015; Platt et al., 1998).

The Marlow Social Desirability Questionnaire (MC-SDS) assesses individual differences in participant concerns regarding presenting themselves in socially acceptable terms and securing social approval. Research has repeatedly shown that social influence can play a role in in-lab false memory endorsement (Gabbert et al., 2003; Meade & Roediger, 2002; Roediger et al., 2001). Despite this body of work, the possibility of a direct link between social desirability and false memory susceptibility on the misinformation effect has yet to be assessed. While research on false memory implantation of autobiographical memory has not shown a link to social desirability (Hyman & Billings, 1998), work with the misinformation effect in children using interrogative suggestion techniques suggests that there might be a weak association between these variables (Lee, 2004). Given the need for additional filler questionnaires and the relatively low cost of exploring this link, the MC-SDS Questionnaire was administered in this study.

2.1 Methods

2.1.1 Participants

Eighty-seven participants (59 female, mean age=19.33, SD =1.59, range 18-25) participated in this study, a sample size selected for providing sufficient power to detect medium effect sizes of $\rho \geq .30$. All participants were recruited from the UNL Psychology
Department subject pool via an online research participation platform (SONA). The University’s IRB approved all procedures with participants providing informed consent and receiving 1.5 hours of research credit for their participation.

2.1.2 Procedure

After providing informed consent, participants completed a brief demographics measure. They then completed the misinformation study phase followed by the picture-word study phase. These study phases were followed by approximately 15-minutes of filler tasks including a short form version of the Marlow Social Desirability Questionnaire and a rating task in which participants were presented with scene-object pairings (e.g., kitchen-knife) and asked to rate how typical those pairings were. None of these items were critical details in either the picture-word or misinformation task. After completing these tasks, participants completed the misinformation narrative phase followed by the picture-word test phase, the Dissociative Experiences Questionnaire and, finally, the misinformation test phase.

2.1.3 Materials

Demographics measure: This measure contained two items. The first asked participants to enter their age in years by typing it in while the second asked them to indicate their self-identified gender.

Marlow Social Desirability Questionnaire Short Form: The original MC-SDS (King & Bruner, 2000) is a 33-item self-report questionnaire that aims to assess individual differences in participant concerns regarding presenting themselves in socially acceptable
terms and securing social approval. The 13-item short form version used in this study was
developed by Reynolds (1982) drawing on prior work by (Strahan & Gerbasi, 1972).
Reynolds (1982) found this short-form version to be very highly correlated with the full
MC-SDS (r = .93), demonstrating a similar level of cross-scale validity with other
measures of social desirability such as the Edwards Social Desirability Scale (Edwards &
Walker, 1961) (full MC-SDS: r = .47, short form : r = .41) . Unfortunately, scores on this
scale did not exhibit a good level of internal consistency in Study 1’s sample (α=.24).

Dissociative Experiences Questionnaire: The DES (Bernstein & Putnam, 1986) is a 28
item self-report inventory (with no reverse coding) utilizing an 11-point frequency
anchored response scale ranging from 0% to 100% in increasing 10% increments. Items
on the scale are designed to tap into dissociative tendencies (i.e. deviations from the
normal integrated sense of conscious experience) with statements such as “Some people
have the experience of finding themselves in a place and having no idea how they got
there” and “Some people have the experience of drinking a car and suddenly realizing
that they don’t remember what has happened during all or part of the trip”. Scores on this
scale exhibited high levels of internal consistency in this study (α = 0.89)

Picture-word source monitoring task: This task consisted of a single study and test phase.
During the study phase, 62 commonplace objects were presented to the participant, one at
a time in random order. All images used were obtained from the Bank of Standardized
stimuli (BOSS) database (Brodeur et al., 2010; Brodeur et al., 2014), a normative set of
images publically accessible at https://sites.google.com/site/bosstimuli/. A list of the
names of all objects used in this task is presented in Appendix A.
Each object was presented to the participant either as a picture or as a word with presentation type being counterbalanced across two counterbalanced conditions. While each object as being presented, participants were asked to write down two possible uses for the object on a piece of paper. Each object was presented onscreen for 8 seconds each after which the object was removed from the screen and replaced with the word “Stop”. This word remained on screen for 2 seconds before being replaced with a fixation sign for 1 second followed by the next object in the sequence. During the test phase, the names of 77 objects (31 previously presented as pictures, 31 as words, 15 that were never presented) were read out to them one at a time. After the name of an object has been read out, participants were asked to indicate whether that object was presented during the study phase as a picture (“Picture”), as a word (“Word”) or whether it was not presented at all (“New”). No time limit was imposed for this decision.

Misinformation effect task: This task had three phases, event study, misinformation exposure and test. In the study phase, participants viewed two events sequentially, each depicted in a series of 50 digital color slides (from Okado & Stark, 2005). These distinct events depicted (1) a man breaking into a car and (2) a woman’s wallet being stolen. The presentation order of the events was randomized across participants. Each slide was presented for 3500 ms with a 500 ms blank screen between slides.

During the misinformation exposure phase, participants studied two narratives (Narratives 1 and 2 in Appendix B) with each purportedly redescribing one of the previously presented events. Participants were explicitly told that their memory for these events would be tested at a later point in the study. Each narrative consisted of 50 sentences, one for each event slide. In an attempt to equalize the amount of study time
between the verbal and visual study stages as well as standardize the amount of overall reading time, each sentence was presented for 3500 ms with a 500 ms blank screen between sentences. Details from 24 slides (12 from each event) were selected for testing, 12 of these details were described inaccurately as the misinformation condition whereas the other 12 were mentioned consistently in the narrative as the control condition. The use of consistent control items is a type of control utilized in a considerable number of misinformation effect studies (e.g. Calvillo, 2014; Wang et al., 2014; Zhu et al., 2013; Zhu, Chen, Loftus, Lin, He, Chen, Li, Moyzis, et al., 2010) and was utilized here in anticipation of Study 3.

Assignment of event item details to misinformation/control status was not counterbalanced in Study 1. In other words, which specific event item details were assigned to the misled versus control conditions were fixed for all participants. This design choice was made in anticipation of the need to develop a version of the misinformation effect task with a sufficiently high number of misled details for the neuroimaging investigation presented in Study 3. However, the type of misinformation presented regarding the misled details was varied between participants with two different versions of each event were used in this experiment with participants being randomly assigned to view one of the two. As shown in Table 1, the misinformation provided for each version was in agreement with what was presented in the other variant. For example, if in version A, cocaine was present in the trunk with the misinformation stating it was marijuana, in version B, marijuana was present in the trunk, with the misinformation stating it was cocaine.
Table 1: Study 1 Counterbalancing Strategy

<table>
<thead>
<tr>
<th>Set</th>
<th>Event Version Viewed</th>
<th>Misinformation Version Read</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 A</td>
<td>(Target uses a hanger to open a door)</td>
<td>(“He used a card to open the door”)</td>
</tr>
<tr>
<td>2 B</td>
<td>(Target uses a card to open a door)</td>
<td>(“He used a hanger to open the door”)</td>
</tr>
</tbody>
</table>

During the testing phase, participants were tested on all 12 verbally misled details as well as 12 control event details which were shown in the event and mentioned consistently in the narrative. A True/False test format with a source monitoring assessment was used where the critical sentences were presented on screen one at a time with buttons labeled “True” and “False” underneath them for participants to select via mouse click. After making their selection, participants were asked to indicate whether that response had been made based on something they remembered seeing (“Seen”), reading (“Read”), both seeing or reading (“Both Seen & Read”) or whether they had simply been guessing (“Neither”).

2.2 Results

2.2.1 Misinformation Task: Behavioral Data

Test performance is presented in Tables 2 through 5. Tables 2 and 3 show the breakdown of mean frequencies for event and misled items as a function of endorsement (“true”) versus rejection (“false”) and subsequent source judgment. Tables 4 and 5 presents the same breakdown for these items as a proportion of the total number of items.
presented in each condition, which was 12. “Seen” and “Seen & Read” responses (i.e., perceptual attributions), was the critical response category focused on in subsequent analyses.

*Table 2: Study 1 Control Event Item Response Frequencies and Standard Deviations*

<table>
<thead>
<tr>
<th>Response</th>
<th>Seen</th>
<th>Seen &amp; Read</th>
<th>Perceptual Attribution</th>
<th>Read</th>
<th>Guess</th>
</tr>
</thead>
<tbody>
<tr>
<td>True</td>
<td>2.08 (2.04)</td>
<td>6.69 (2.62)</td>
<td>8.77 (1.88)</td>
<td>.90 (1.12)</td>
<td>.11 (.39)</td>
</tr>
<tr>
<td>False</td>
<td>1.11 (1.22)</td>
<td>.46 (.84)</td>
<td>1.57 (1.46)</td>
<td>.14 (.44)</td>
<td>.48 (.87)</td>
</tr>
</tbody>
</table>

*Table 3: Study 1 Misled Event Item Response Frequencies and Standard Deviations*

<table>
<thead>
<tr>
<th>Response</th>
<th>Seen</th>
<th>Seen &amp; Read</th>
<th>Perceptual Attribution</th>
<th>Read</th>
<th>Guess</th>
</tr>
</thead>
<tbody>
<tr>
<td>True</td>
<td>.46 (.76)</td>
<td>1.70 (1.48)</td>
<td>2.16 (1.61)</td>
<td>2.72 (3.20)</td>
<td>.08 (.31)</td>
</tr>
<tr>
<td>False</td>
<td>4.89 (3.85)</td>
<td>.67 (1.00)</td>
<td>5.55 (3.83)</td>
<td>.77 (2.05)</td>
<td>.71 (1.11)</td>
</tr>
</tbody>
</table>

*Table 4: Study 1 Control Event Item Response Proportions and Standard Deviations*

<table>
<thead>
<tr>
<th>Response</th>
<th>Seen</th>
<th>Seen &amp; Read</th>
<th>Perceptual Attribution</th>
<th>Read</th>
<th>Guess</th>
</tr>
</thead>
<tbody>
<tr>
<td>True</td>
<td>.17 (.17)</td>
<td>.56 (.22)</td>
<td>.73 (.16)</td>
<td>.07 (.09)</td>
<td>.01 (.03)</td>
</tr>
<tr>
<td>False</td>
<td>.09 (.10)</td>
<td>.04 (.07)</td>
<td>.13 (.12)</td>
<td>.01 (.03)</td>
<td>.04 (.07)</td>
</tr>
</tbody>
</table>
Table 5: Study 1 Misled Item Response Proportions and Standard Deviations

<table>
<thead>
<tr>
<th>Response</th>
<th>Seen</th>
<th>Seen &amp; Read</th>
<th>Perceptual Attribution</th>
<th>Read</th>
<th>Guess</th>
</tr>
</thead>
<tbody>
<tr>
<td>True</td>
<td>.04 (.06)</td>
<td>.14 (.12)</td>
<td>.18 (.13)</td>
<td>.22 (.27)</td>
<td>.01 (.03)</td>
</tr>
<tr>
<td>False</td>
<td>.41 (.32)</td>
<td>.05 (.08)</td>
<td>.46 (.32)</td>
<td>.06 (.17)</td>
<td>.06 (.09)</td>
</tr>
</tbody>
</table>

Pairwise t-tests indicated that participants made more control event item endorsements than misled item endorsements with perceptual attributions (t(86) = 7.405, p < .001), and a greater number of perceptual based misled item rejections than misled item endorsements (t(86) = 5.012, p < .001). Participants were also more likely to perceptually endorse misled items than perceptually reject control items (t(86) = 2.494, p = .015). None of the response frequencies in the critical response categories of interest differed significantly based on which version of the misinformation participants received (all p’s > .35). Intercorrelations between the primary variables of interest are presented in Table 6. The full correlation matrix between all responses is presented in Appendix C. Note that correlations within the misinformation and control item groups are not independent as an endorsed control or misinformation item cannot also be rejected.
Table 6: Study 1 Correlations between Misinformation Test Responses with Perceptual Attributions

<table>
<thead>
<tr>
<th></th>
<th>Perceptual Misled Item Endorsements</th>
<th>Perceptual Misled Item Rejections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceptual Event Item Endorsements</td>
<td>-.23*</td>
<td>.08</td>
</tr>
<tr>
<td>Perceptual Misled Item Endorsements</td>
<td>-</td>
<td>-.43**</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

2.2.2 Picture-Word Behavioral Data

Response frequencies and proportions on the Picture-Word test task are presented in Tables 7 and 8, respectively. Pairwise t-tests indicated that participants were more likely to correctly attribute items shown as words as being presented as words relative to misattributing them as having been presented as pictures (MD = 24.40, SD = 6.12, t(86) = 37.16, p < .001) or unpresented items (MD = 25.39, SD = 5.05, t(86) = 46.88, p < .001). Participants were also more likely to correctly attribute items shown as pictures as being presented as pictures relative to misattributing them as having been presented as words (MD = 27.57, SD = 4.49, t(86) = 57.29, p < .001) or unpresented items (MD = 27.31, SD = 4.48, t(86) = 56.75, p < .001. Participants also more frequently correctly categorized unpresented items as “new” relative to misattributing them as being presented as pictures (MD = 12.59, SD = 2.94, t(86) = 39.94, p < .001) or items presented as words (MD = 11.65, SD = 3.84, t(86) = 28.29, p < .001). Finally, participants were more likely to
misattribute new items as being presented as words as opposed to pictures (MD = .93, SD = 1.61, t(86) = 5.39, p < .001).

Table 7: Study 1 Picture Word Task Response Frequencies and Standard Deviations

<table>
<thead>
<tr>
<th>Response</th>
<th>Shown As</th>
<th>Picture</th>
<th>Word</th>
<th>New</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picture</td>
<td></td>
<td>28.63 (3.00)</td>
<td><strong>1.06 (1.65)</strong></td>
<td>1.32 (1.81)</td>
</tr>
<tr>
<td>Word</td>
<td></td>
<td><strong>2.53 (2.77)</strong></td>
<td>26.93 (3.60)</td>
<td>1.54 (1.92)</td>
</tr>
<tr>
<td>Not-Shown</td>
<td></td>
<td>.49 (.93)</td>
<td>1.43 (1.70)</td>
<td>13.08 (2.21)</td>
</tr>
</tbody>
</table>

Table 8: Study 1 Picture Word Task Response Proportions and Standard Deviations

<table>
<thead>
<tr>
<th>Response</th>
<th>Shown As</th>
<th>Picture</th>
<th>Word</th>
<th>New</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picture</td>
<td></td>
<td>.92 (.09)</td>
<td>.03 (.05)</td>
<td>.04 (.06)</td>
</tr>
<tr>
<td>Word</td>
<td></td>
<td>.08 (.09)</td>
<td>.87 (.12)</td>
<td>.05 (.06)</td>
</tr>
<tr>
<td>Not-Shown</td>
<td></td>
<td>.03 (.06)</td>
<td>.09 (.11)</td>
<td>.87 (.14)</td>
</tr>
</tbody>
</table>

2.2.3 Picture-Word & Misinformation Effect Links

Linear random intercept models with robust standard errors (Huber, 1967), an estimation procedure resistant to violations of heteroscedasticity, were used to model the relationship between misinformation susceptibility (DV1) and control item endorsements (DV2) and “Picture-As-Word” (IV1) as well as “Word-As-Picture” (IV2) source
monitoring errors. These relationships were modeled in two separate models with the Picture-As-Word and Word-As-Picture errors being entered simultaneously as predictor variables. All reported beta values can be interpreted as indicating the estimated average increase in the number of misinformation endorsements for every one additional source monitoring task error. A Bonferroni correction procedure was applied to each model, keeping the family-wise type-1 error rate of each separate model at p = .05.

The results of these analyses showed that Word-As-Picture errors had a marginally negative relationship with misinformation susceptibility as seen in the perceptual endorsement of misled items (B = -.12, SE = .06, F(1,84) = 3.68, p = .057), while Picture-As-Word errors had a significantly positive one (B = .32, SE = .13, F(1,84) = 5.81, p = .018). Word-As-Picture errors were not significantly related to control item perceptual endorsement levels (B = -.04 SE = .07, F(1,84) = .33, p = .565) while Picture-As-Word errors were significantly negatively related to this performance variable (B = -.36, SE = .18, F(1,84) = 4.12, p = .045). In summary, higher levels of Word-As-Picture errors were marginally associated with fewer perceptual misinformation endorsements while higher levels of Picture-As-Word errors were associated with both increased levels of perceptual misinformation endorsement and reduced levels of accurate perceptual control item endorsement levels.

2.2.4 Personality Inventories & Picture-Word Task Links

Bonferroni corrected correlations between the administered personality measures and responses on the picture-word task and are presented in Table 9. None of the personality measures were significantly related to any of the Picture-Word task response rates.
Table 9: Study 1 Personality Inventories & Picture-Word Response Correlations

<table>
<thead>
<tr>
<th></th>
<th>Picture-As-Word</th>
<th>Word-As-Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC-SDS</td>
<td>-.13</td>
<td>.11</td>
</tr>
<tr>
<td>DES</td>
<td>-.12</td>
<td>.07</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

2.2.5 Personality Inventories & Misinformation Effect Links

A significant correlation was noted between the MC-SDS and DES scales, \( r(87) = .293, p = .006 \). This result suggests that higher levels of concern regarding social presentation (MC-SDS) are significantly associated with dissociative tendencies. While intriguing, exploring the potential nature of this link is beyond the scope of the current dissertation. With regard to the primary measure of this study, intercorrelations between the personality inventories and the primary misinformation task responses are in presented in Table 10. None of the personality measures were significantly directly correlated with any of the primary misinformation task response rates either pre- or post-Bonferroni correction. It is important, however, to note that MC-SDS scores exhibited poor levels of internal consistency (\( \alpha = .24 \)) in this sample, limiting the inferences that can be drawn from them.
Table 10: Study 1 Personality Inventories & Misinformation Response Correlations

<table>
<thead>
<tr>
<th></th>
<th>Perceptual Event Item Endorsements</th>
<th>Perceptual Misled Item Endorsements</th>
<th>Perceptual Misled Item Rejections</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC-SDS</td>
<td>&gt; .01</td>
<td>.07</td>
<td>.19</td>
</tr>
<tr>
<td>DES</td>
<td>.03</td>
<td>-.06</td>
<td>.16</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

The potential moderating role of these personality measure scores on the observed links between Picture-As-Word and Word-As-Picture errors was also assessed by individually adding these variables to the models presented in section 2.3.3 as fully interacting variables. The results of these analyses showed that DES scores were uncorrelated with Picture-As-Word errors ($r(87) = -.08, p = .481$) and Word-As-Picture errors ($r(87) = -.12, p = .27$). DES scores also did not significantly predict misinformation error rates on their own ($r(87) = -.06, p = .560$) or after controlling for Word-As-Picture and Picture-As-Word errors, $B < .001$, $SE = .006$, $F(1,81) = .01$, $p = .942$. DES scores also did not show a moderating effect on the link between Picture-As-Word or Word-As-Picture errors and misinformation susceptibility ($B < .001$, $SE = .004$, $F(1,81) = .02$, $p = .879$ and $B < .001$, $SE = .001$, $F(1,81) = .87$, $p = .353$ respectively). Picture-As-Word errors also continued to significantly predict misinformation errors ($B = .310$, $SE = .137$, $F(1,81) = 5.14$, $p = .026$) after controlling for DES scores. The link between Word-As-Picture errors and misinformation susceptibility was marginally negative in this model ($B = -.114$, $SE = .064$, $F(1,81) = 3.13$, $p = .080$).
The results of these analyses also showed that MC-SDS scores were uncorrelated with Picture-As-Word errors (r(87) = -.13, p = .232) and Word-As-Picture errors (r(87) = .11, p = .32). SDS scores also did not significantly predict misinformation susceptibility on their own (r(87) = .07, p = .528), or after controlling for Word-As-Picture and Picture-As-Word errors, B = .067, SE = .059, F(1,81) = 1.88, p = .174). While moderation effects involving the MC-SDS were not anticipated, these effects were nonetheless assessed for completeness. In these analyses, MC-SDS scores also did not show a moderating effect on the link between Picture-As-Word or Word-As-Picture errors and misinformation susceptibility (B = -.003, SE = .033, F(1,81) = .01, p = .921 and B = -.023, SE = .019, F(1,81) = 1.42, p = .238 respectively). Picture-As-Word errors also continued to significantly predict misinformation errors (B = .342, SE = .115, F(1,81) = 8.84, p = .003) after controlling for MC-SDS scores. The relationship between Word-As-Picture errors and misinformation susceptibility was also significantly negative (B = -.126, SE = .061, F(1,81) = 4.19, p = .044) in this model.

2.3 Study 1 Discussion

In line with Specific Aim 1 (i.e. the contrasting of differences in the strength of the association between misinformation susceptibility and basic visual as well as verbal source monitoring errors), the results of Study 1 show a significantly stronger link between misinformation susceptibility and verbalization source monitoring attribution errors (i.e., Picture-As-Word) relative to visualization errors (i.e., Word-As-Picture) on the picture-word source monitoring task. Specifically, higher levels of Word-As-Picture errors were marginally associated with fewer perceptual misinformation endorsements
while higher levels of Picture-As-Word errors were associated with both increased levels of perceptual misinformation endorsement and reduced levels of accurate perceptual control item endorsement levels.

These results suggest that misinformation endorsements may be more strongly associated with verbalization based source monitoring errors relative to visualization focused ones. In other words, the perceptual endorsement of misleading postevent information is more strongly driven by the processes related to source misattributions of verbal or narrative related encoding. These findings are in line with theoretical work emphasizing the importance of verbal and narrative processing in the misinformation effect (see Section 1.5). Of particular relevance, they are congruent with Zaragoza et al. (2011)’s findings on how reflecting on conceptual aspects of misinformation material can lead to even greater levels of perceptual misinformation endorsements relative to visualization based perceptual elaboration.

In addition to these primary results, Study 1 also showed the MC-SDS and DES to have no direct or indirect links to misinformation susceptibility in this target population; though it should be noted that MC-SDS scores exhibited poor levels of internal consistency in this study’s sample. The observed verbalization link was also shown to be independent of these two measures. These null results regarding direct links to misinformation susceptibility are in line with prior work in this area involving the MC-SDS (Hyman & Billings, 1998) and DES (Drivdahl & Zaragoza, 2001; Eisen, Morgan, et al., 2002; Monds et al., 2013; Otgaar et al., 2017; Zhu, Chen, Loftus, Lin, He, Chen, Li, Moyzis, et al., 2010) scales. Of primary importance to the focus of this dissertation is the null result regarding indirect links involving the DES, Picture-Word source monitoring
performance and misinformation susceptibility. The absence of significant moderated links between these measures suggests that it is not the case that a link between visualization and misinformation susceptibility emerges among individuals with higher levels of dissociative tendencies, a group which may perhaps be particularly likely to demonstrate such an association. Instead, verbalization source monitoring errors appear to have a significantly stronger role in misinformation susceptibility regardless of individual differences in the propensity towards dissociative experiences.

Study 2

3.1 Study 2: Introduction

The goal of Study 2 is to achieve Specific Aim 2 of this dissertation (i.e., to test the robustness and replicability of detected relationships between misinformation susceptibility and basic visual as well as verbal source monitoring errors).

As discussed in the preface to Study 1, the True/False test format on the misinformation effect has several distinct advantages such as the direct targeting of specific event memories. Nonetheless there are numerous other testing formats frequently used to assess memory performance on the misinformation effect paradigm such as cued recall (Chan & Lapaglia, 2011; Chan & LaPaglia, 2013; Stephen Lindsay et al., 2004), free recall (Huff et al., 2016; Wilford et al., 2014) and two-alternative force-choice (2AFC) tests (Bonto & Payne, 1991; Loftus et al., 1978; Oeberst & Blank, 2012). Of these variants, the 2AFC format is particularly interesting to consider. In a standard administration of a 2AFC misinformation test, participants are presented with questions involving event details presented alongside two response options. These options are typically either a control and foil item or a control and misinformation option. As a result
of this simultaneous presentation of event and misinformation recognition cues, the 2AFC test arguably represents a more powerful test of the impact of misinformation on memory as participants are directly presented with cues prompting retrieval of both the event and misinformation memory traces.

The goal of Study 2 is to replicate the findings of Study 1 using this more robust assessment of misinformation susceptibility. To achieve this aim, the same procedure utilized in Study 1 was administered in Study 2, albeit with a 2AFC misinformation test measure instead of a true/false test. The primary hypothesis of Study 2 is that, as in Study 1, verbalization error rates will be more strongly predictive of misinformation susceptibility than visualization error rates. Given the potentially increased role for visual-based strategies on the 2AFC test, however, the relationship between Picture-As-Word errors and misinformation susceptibility was anticipated to be weaker in Study 2.

The Creative Experiences Questionnaire (CEQ) was administered in this study as a replacement for DES from Study 1. The CEQ is a self-report measure of individual differences in imagination vividness and fantasy proneness (Merckelbach et al., 2001). While researchers have repeatedly failed to find a link between misinformation susceptibility and CEQ scores (Desjarlais & Bernstein, 2012; though see Frost et al., 2013 for a discussion the potential moderating influence of retention interval; Greening, 2002; Merckelbach et al., 2000), the inventory was administered in this study to test the possibility of a visualization-misinformation susceptibility link being present among individuals with high levels of fantasy proneness.

A second measure, the Internal/External Encoding Style Questionnaire was also administered with a similar goal. The Internal/External Encoding Style Questionnaire
(Lewicki, 2005) assess individual differences in how information encoding draws on external (i.e., environmental) versus internal (i.e., internal mental schemata) cues. Like the CEQ, this inventory was administered in this study to test the possibility of a visualization-misinformation susceptibility link being present among individuals who indicated a greater tendency to rely on internal sources of information.

Finally, the VVIQ was administered in this study as a measure of visualization vividness. Extensively discussed in the introduction section (see Section 1.4), the VVIQ (Marks, 1973) is a measure of individual differences in visual imagery vividness. While the VVIQ is usually shown to be uncorrelated with misinformation susceptibility (Desjarlais & Bernstein, 2012; Greening, 2002; Nichols, 2014), it is possible that individuals with higher levels of visualization vividness may show a stronger link between visualization and misinformation susceptibility relative to individuals with lower levels of mental imagery vividness. To assess this possibility, the VVIQ was administered in this study.

3.2 Methods

3.2.1 Procedure

After providing informed consent, participants completed a brief demographics measure. They then completed the misinformation study phase followed by the picture-word study phase. These study phases were followed by approximately 15 minutes of filler tasks consisting of the Creative Experiences Questionnaire (CEQ) and the Internal/External Encoding Style Questionnaire personality inventory. After completing these tasks, participants completed the misinformation narrative study phase after which
they completed the VVIQ inventory (5 minutes), the misinformation test phase and the picture-word test phase.

3.2.2 Participants

In order to more robustly assess the effects observed in Study 1, a larger sample of 179 participants (135 female, mean age=19.52, SD =2.67, range 18-28) was recruited in Study 2, with the larger sample providing additional power to compensate for the anticipated power loss arising from the impact of the 2AFC test on the misinformation effect’s magnitude. All participants were recruited from the UNL Psychology Department subject pool via an online research participation platform (SONA). The local IRB approved all procedures with participants providing informed consent and receiving 1.5 hours of research credit for their participation.

3.2.3 Materials

*Demographics measure:* The same demographics measure used in Study 1 was also used in Study 2 with one minor modification in which the gender item was changed from a choice selection option to a fill-in-the-blank response format.

*Creative Experiences Questionnaire (CEQ):* The CEQ (Merckelbach et al., 2001) is a questionnaire which assesses fantasy proneness, defined as a combination of the strength of one’s imagination and one’s inclination towards engaging in imagination/fantasy related activities. The CEQ was developed to be a viable alternative to the Inventory of Childhood Memories and Imaginings which the authors of the CEQ considered to be overly long. The CEQ contains 25 items such as “Currently, I spend more than half the
day (daytime) fantasizing or daydreaming) and “I often confuse fantasies with real memories”, all of which are self-report with a dichotomous yes/no response format. Scores on this scale exhibited moderate levels of internal consistency in this study (α = 0.82)

*Internal/External Encoding Style Questionnaire (NISROE):* The NISROE (Lewicki, 2005) questionnaire aims to assess individual differences in how information encoding draws on external (i.e., based on data from the environment) versus internal (i.e., based on data from preexisting mental schemata) cues. The questionnaire consists of 21-items comprised of 15 filler items and 6 critical items (e.g. “For a split second from a distance, I sometimes mistake strangers for people I know”, “I’ve sometimes noticed a particular object to my left or right, and only after I turned my head I realized it was something else” each of which is rated on a 6-point Likert scale with 1 indicating strong disagreement and 6 indicating strong agreement. Higher scores on the inventory are indicative of a greater reliance on internal sources of information during information encoding. Scores on this scale exhibited acceptable levels of internal reliability in this study (α = 0.66).

*Vividness of Visual Imagery Questionnaire (VVIQ):* The VVIQ (Marks, 1973) is a 16-item measure of individual differences in visual imagery which builds on the Betts Questionnaire upon Mental Imagery (Sheehan, 1967). The VVIQ verbally instructs participants to visually image specific details of specific visual scenes and record the vividness of the imagery on a five-point scale (e.g., “Close your eyes and think of some relative of a friend who you frequently see. Consider carefully the picture that comes before your mind’s eye” followed by instructions to rate the vividness of “The exact
contour of face, head, shoulders, and body then rate the exact contour of face, head, shoulders, and body”). Higher scores on the VVIQ are indicative of higher levels of visualization strength. This measure of visual imagery has been widely used in hundreds of studies to investigate the role of subjective visualization vividness across a wide range of domains (see McKelvie, 1995 for a review). Scores on this scale exhibited high levels of internal reliability in this study ($\alpha = 0.88$).

*Picture-word source monitoring task:* This picture-word task used in Study 2 was effectively identical to the one used in Study 1. The sole change made was the adjustment of the number of stimuli from 31 pictures, 31 words and 15 new items to 30 pictures, 30 words and 17 new items upon the realization that one of the items used in the picture-word task (a hanger) was also a critical item in the misinformation test task. This item was discarded from the study set along with another randomly selected item for counterbalancing purposes.

*Misinformation effect task:* The basic structure of the misinformation task used in Study 1 was reused in this study with the following changes: (1) the counterbalancing system was expanded, (2) the test format was changed from a True/False format to a 2AFC structure. As in Study 1, Participants were explicitly told that their memory for these events would be tested at a later point in the study.

The counterbalancing strategy employed in Study 2 ensured that each critical item served as an event and misled item equally often (i.e., assignment of items to the control and misled conditions was fully counterbalanced). To achieve this, two different event versions of each scenario were used, version A and version B. Accordingly, in each event version, critical event details from 12 event slides had two possible variants, one which
was shown to any given participant. For each event version, half of those details were randomly assigned to group X whereas the other half were assigned to group Y. Item groups X and Y were then assigned to either the control or misinformation conditions creating four combination conditions for each presented scenario. Table 11 presents the procedure for a single scenario. Items assigned to the misinformed condition in each combination (i.e., Set 1A) were described inaccurately in the narrative in a manner which matched how they were presented in the other event version (e.g., version 1B) whereas the control items were consistently described neutrally in the narrative (neutral control). The first and second event sets were then randomly paired to produce four experimental conditions to which participants were then randomly assigned to.

As an example, version A presented a man breaking into a car with a hanger and finding cocaine whereas version B presented a man breaking into a car with a credit card and finding marijuana. The object used to break into the car and what was found were then assigned to item group X and Y respectively. In example, Set 1A would present the man breaking into a car with a **hanger** and finding **cocaine** with the narrative reading “He used a **credit card** to open the car door” and “He **pulled out a bag of drugs**”; Set 2A would present the man breaking into a car with a **hanger** and finding **cocaine** with the narrative “He used a **tool** to open the car door” and “He **pulled out a bag of marijuana**.”; Set 1B would present a man breaking into a car with a **card** and finding **marijuana** with the narrative reading “‘He used a **hanger** to open the car door” and “He **pulled out a bag of drugs**”; Set 2B would present a man breaking into a car with a **card** and finding **marijuana** with the narrative reading He used a **tool** to open the car door” and “**He pulled out a bag of cocaine**”.

Table 11: Study 2 Counterbalancing Strategy

<table>
<thead>
<tr>
<th></th>
<th>Event Version Viewed</th>
<th>Misinformed Items</th>
<th>Neutral Control Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set 1A</td>
<td>A</td>
<td>Group X</td>
<td>Group Y</td>
</tr>
<tr>
<td>Set 2A</td>
<td>A</td>
<td>Group Y</td>
<td>Group X</td>
</tr>
<tr>
<td>Set 1B</td>
<td>B</td>
<td>Group X</td>
<td>Group Y</td>
</tr>
<tr>
<td>Set 2B</td>
<td>B</td>
<td>Group Y</td>
<td>Group X</td>
</tr>
</tbody>
</table>

In the 2AFC test used, participants were presented with a series of questions and two response options. On questions involving sentences that had been targets of misinformation, the two options were the original event item detail and the misinformation-based detail (misled item) whereas on questions involving neutral control sentences, the two options were the original item and a foil item which corresponded to the misinformation detail presented in the condition in which the detail was assigned to the misinformed condition (i.e., The foil options in 1A matched the misinformation details in 1B and vice versa). Continuing with the example in the previous paragraph, all sets would ask participants to indicate which response detail accurately matched the event with the response options being hanger/card and cocaine/marijuana for the questions “What did the man use to break into the car” and “What did the man find in the car”. Participants made their responses by clicking on the corresponding option via mouse click. After making their selection, participants were asked to indicate whether that response had been made based on something remembered seeing (saw), reading (read), both seeing or reading (both) or whether they had simply been guessing (neither). For each participant, the test consisted of 12 event item versus foil item 2AFC questions,
12 event item versus misled item 2AFC questions, and 12 filler 2AFC test questions based on non-critical shown and notShown items.

3.3 Results

3.3.1 Misinformation Task: Behavioral Data

Performance on the misinformation test is presented in Tables 12 through 15. Tables 12 and 13 show the breakdown of response within the control condition as a function of endorsement versus rejection selection and their subsequent source judgment attributions. Table 14 and 15 present the same breakdown for the misled condition. Detail endorsements given “Seen” and “Seen & Read” responses (i.e., perceptual attributions), are the critical response categories focused on in subsequent analyses. With regard to terminology, the term misled condition refers to all the test questions concerning details which were subjected to misinformation whereas the phrase misled item refers to individual misled event details.

Table 12: Study 2 Control Condition Response Frequencies and Standard Deviations

<table>
<thead>
<tr>
<th>Selection</th>
<th>Seen</th>
<th>Seen &amp; Read</th>
<th>Perceptual Attribution</th>
<th>Read</th>
<th>Guess</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event Item</td>
<td>5.94 (2.23)</td>
<td>1.45 (1.27)</td>
<td>7.40 (2.16)</td>
<td>.45 (.76)</td>
<td>1.08 (1.21)</td>
</tr>
<tr>
<td>Foil</td>
<td>.41 (1.19)</td>
<td>.47 (.62)</td>
<td>.87 (.98)</td>
<td>1.13 (1.07)</td>
<td>1.06 (1.20)</td>
</tr>
</tbody>
</table>
Within the control test condition, participants made more accurate perceptual event item selections relative to foil selections ($t(178) = 32.88$, $p < .001$). Within the misled condition, participants also made more accurate perceptual event item selections relative to misled item selections ($t(178) = 19.33$, $p < .001$). A significant misinformation
effect was present with participants being likely to perceptually endorse misled items as opposed to matched foil responses in control items ($t(178) = 5.67, p < .001$). Participants were also less likely to correctly select and perceptually endorse event items that were subjected to misinformation (i.e., event item selections in the misled condition) relative to items that were not (i.e., event item selections in the control condition), $t(178) = 6.68, p < .001$. It is important to note, however, that the last two tests are not independent given the 2AFC testing format used in this study.

Intercorrelations between the primary variables of interest are presented in table 16. The full correlation matrix for all responses is presented in Appendix D. Note that correlations within the misinformation and control item groups are not completely independent as an endorsed control or misinformation selection response removes the possibility of a foil selection or event item response respectively.

\textit{Table 16: Study 2 Correlations between misinformation test response selections with perceptual attributions}

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Misled</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Foil Item</td>
<td>Event Item</td>
</tr>
<tr>
<td>Control</td>
<td>-</td>
<td>-.32**</td>
</tr>
<tr>
<td>Event Item</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Misled</td>
<td>Event Item</td>
<td>-</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
3.3.2 Picture-Word Task Behavioral Data

Response proportions on the Picture-Word test task are presented in tables 17 and 18. Pairwise t-tests indicated that participants were more likely to correctly attribute items shown as words as being presented as words relative to misattributing them as having been pictures (MD = 22.30, SD = 6.94, t(178) = 43.01, p < .001) or unpresented items (MD = 24.44, SD = 5.30, t(178) = 61.67, <.001). Participants were also more likely to correctly attribute items shown as pictures as being presented as pictures relative to misattributing them as having been words (MD = 26.78, SD = 5.10, t(178) = 70.24, p < .001) or unpresented items (MD = 25.93, SD = 4.85, t(178) = 71.58, <.001). Participants also more frequently correctly categorized unpresented items as “new” relative to misattributing them as having been originally presented as pictures (MD = 14.23, SD = 3.88, t(178) = 49.01, <.001) or words (MD = 13.87, SD = 4.64, t(178) = 40.03, p < .001). Finally, replicating the effect from Study 1, participants were more likely to misattribute new items as having being presented as words relative to pictures (MD = .36, SD = 2.12, t(178) = 2.25, p = .026).

Table 17: Study 2 Picture Word Task Response Frequencies and Standard Deviations

<table>
<thead>
<tr>
<th>Response</th>
<th>Picture</th>
<th>Word</th>
<th>New</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shown As</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Picture</td>
<td>27.57 (3.20)</td>
<td>.79 (2.16)</td>
<td>1.64 (1.95)</td>
</tr>
<tr>
<td>Word</td>
<td>3.28 (3.23)</td>
<td>25.58 (3.94)</td>
<td>1.14 (1.94)</td>
</tr>
<tr>
<td>Not-Shown</td>
<td>.80 (1.40)</td>
<td>1.16 (2.02)</td>
<td>15.03 (2.76)</td>
</tr>
</tbody>
</table>
Table 18: Study 2 Picture Word Task Response Proportions and Standard Deviations

<table>
<thead>
<tr>
<th>Shown As</th>
<th>Response</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Picture</td>
<td>Word</td>
<td>New</td>
<td></td>
</tr>
<tr>
<td>Picture</td>
<td>.92 (.11)</td>
<td>.03 (.07)</td>
<td>.05 (.07)</td>
<td></td>
</tr>
<tr>
<td>Word</td>
<td>.10 (.11)</td>
<td>.85 (.13)</td>
<td>.04 (.06)</td>
<td></td>
</tr>
<tr>
<td>Not-Shown</td>
<td>.05 (.08)</td>
<td>.06 (.12)</td>
<td>.88 (.16)</td>
<td></td>
</tr>
</tbody>
</table>

3.3.3 Picture-Word & Misinformation Effect Behavioral Links

As in Study 1, an independent set of random linear random intercept models with robust standard errors were used to model the predictive relationships between “Picture as Word” (IV1) as well as “Word as Picture” (IV2) source monitoring errors and misinformation test responses with perceptual attributions (i.e. misled item selections in the misled condition given perceptual source attributions (DV1), event item selections in the misled condition given perceptual source attributions (DV2) control items selections in the control condition given perceptual source attributions (DV3) and foil item selections in the control condition given perceptual source attributions (DV4)). All reported beta values can be interpreted as indicating the estimated average increase in misinformation endorsements with for every one additional picture-word task error in the indicated response category. As in Study 1, a Bonferroni correction procedure was applied to each model, keeping the family-wise type 1 error rate of each separate model at p = .05.

The results of this analysis showed that Picture-As-Word errors were again positively related to DV1, perceptual misled item endorsements (B = .11, SE = .03,
F(1,176) = 15.01, p < .001) while Word-As-Picture errors were not significantly related with this measure, (B = .03, SE = .03, F(1,176) = .76, p = .385). Picture-As-Word errors were also negatively related to perceptual DV2, event item selections in the misled condition given perceptual source attributions (B = -.14, SE = .05, F(1,176) = 6.96, p = .009), with Word-As-Picture not being a significant predictor of this measure (B = -.03, SE = .06, F(1,176) = .34 p = .563).

Neither Word as Picture (B = -.06 SE = .04, F(1, 176) = 1.91, p = .169) or Picture as Word errors (B = .10, SE = .07, F(1, 176) = 2.06, p = .153) were significantly related to DV3, event items selections in the control condition given perceptual source attributions. Word as Picture (B = -.03 SE = .02, F(1, 176) = 1.22, p = .271) or Picture as Word errors variable (B = -.01, SE = .03, F(1, 176) = .19, p = .664) were also not significantly related to DV4, foil item selections in the control condition given perceptual source attributions.

3.3.4 Personality Inventories & Picture-Word Task Links

Bonferroni corrected correlations between the administered personality measures and responses on the picture-word task are presented in Table 19. The sole marginally significant correlation noted was between the VVIQ and Word as Picture error rates (r(179) = .19, p = .013). This relationship suggests a weak relationship between the VVIQ and the tendency to misattribute verbal memory traces to a visual source.
Table 19: Study 2 Personality Inventories & Picture-Word Response Correlations

<table>
<thead>
<tr>
<th>Picture as Word</th>
<th>Word as Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>VVIQ</td>
<td>-.03</td>
</tr>
<tr>
<td>NISROE</td>
<td>-.04</td>
</tr>
<tr>
<td>CEQ</td>
<td>.06</td>
</tr>
</tbody>
</table>

** Corrected correlation is significant at the 0.05 level (2-tailed).

3.3.5 Personality Inventories & Misinformation Effect Links

Bonferroni corrected Intercorrelations between the personality inventories are presented in Table 20. The sole relationship that approached conventional levels of significance was one between the VVIQ and NISROE inventory, \( r(179) = .16, p = .038 \), with higher VVIQ scores being associated with higher NISROE scores. This link suggests that higher levels of subjective visualization vividness are weakly associated with a greater inclination towards relying on internal sources of encoding information. This correlation did not, however, survive any form of family-wise p-value correction.

Table 20: Study 2 Correlations between Personality Inventories

<table>
<thead>
<tr>
<th>VVIQ</th>
<th>NISROE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEQ</td>
<td>.02</td>
</tr>
<tr>
<td>VVIQ</td>
<td>-</td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level (2-tailed).
Intercorrelations between the personality inventories and the primary misinformation task responses of interest (i.e., endorsements and rejections with perceptual source attributions) are presented in Table 21. Note that in this matrix, rejections for control and neutral items refers to the selection of foil response in the control condition while misinformation rejection refers to event item selections in the misled condition. A Bonferroni correction procedure was applied to the p-values of the correlations observed between personality inventory scores and performance on the misinformation task. Post-correction, none of the measures demonstrated significant correlations with misinformation task performance though a marginal trend was noted where higher CEQ scores were marginally negatively correlated with the frequency of accurate event item endorsements in the control condition.

Table 21: Study 2 Personality Inventories & Misinformation Response Correlations

<table>
<thead>
<tr>
<th></th>
<th>VVIQ</th>
<th>NISROE</th>
<th>CEQ</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control Condition:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Event Item selection:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>perceptual attributions</td>
<td>-.11</td>
<td>-.07</td>
<td>-.18</td>
</tr>
<tr>
<td><strong>Control Condition:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foil Item selections:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>perceptual attributions</td>
<td>-.03</td>
<td>.05</td>
<td>-.03</td>
</tr>
<tr>
<td><strong>Misinformation Condition:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Misled Item selections:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>perceptual attributions</td>
<td>.08</td>
<td>.03</td>
<td>-.06</td>
</tr>
<tr>
<td><strong>Misinformation Condition:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Event Item selections:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>perceptual attributions</td>
<td>-.02</td>
<td>.15</td>
<td>-.09</td>
</tr>
</tbody>
</table>
The potential moderating role of these personality measure scores on the observed links between Picture-As-Word and Word-As-Picture errors was also assessed by individually adding these variables to the models presented in section 3.3.3 as fully interacting variables.

The results of these analyses showed that VVIQ scores were uncorrelated with picture as word errors ($r(179) = -.03, p = .666$) but were significantly correlated with Word-As-Picture errors ($r(179) = .19, p = .013$). VVIQ scores did not significantly predict misinformation error rates on their own ($r(179) = .08, p = .291$) or after controlling for Word-As-Picture and Picture-As-Word errors, $B = .029, SE = .187, F(1,173) = .02, p = .876$. VVIQ scores also did not show a moderating effect on the link between Picture-As-Word or Word-As-Picture errors and misinformation susceptibility ($B = .067, SE = .062, F(1,173) = 1.19, p = .278$ and $B = .008, SE = .046, F(1,173) = .03, p = .857$ respectively). Picture-As-Word errors also continued to significantly predict misinformation errors ($B = .117, SE = .035, F(1,173) = 11.40, p < .001$) after controlling for VVIQ scores.

NISROE scores were uncorrelated with Picture-As-Word errors ($r(179) = -.04, p = .595$) or Word-As-Picture errors ($r(179) = .02, p = .781$). NISROE scores also did not significantly predict misinformation error rates on their own ($r(179) = .03, p = .660$) or after controlling for Word-As-Picture and Picture-As-Word errors, $B = .064, SE = .045, F(1,173) = 2.01, p = .158$. NISROE scores also did not show a moderating effect on the link between Picture-As-Word or Word-As-Picture errors and misinformation susceptibility ($B = -.011, SE = .020, F(1,173) = .31, p = .579$ and $B = .010, SE = .012, F(1,173) = .69, p = .406$ respectively). Picture-As-Word errors also continued to
significantly predict misinformation errors (B = .109, SE = .043, F(1,173) = 6.50, p = .0012) after controlling for NISROE scores.

Finally, CEQ scores were uncorrelated with between Picture-As-Word errors (r(179) = -.06, p = .446) or Word-As-Picture errors (r(179) = -.01, p = .866). CEQ scores also did not significantly predict misinformation error rates on their own (r(179) = -.06, p = .845) or after controlling for Word-As-Picture and Picture-As-Word errors, B = .013, SE = .017, F(1,173) = .60, p = .439. CEQ scores also did not show a moderating effect on the link between Picture-As-Word or Word-As-Picture errors and misinformation susceptibility (B = .014, SE = .010, F(1,173) = 1.38, p = .170 and B < .001, SE = .003, F(1,173) = .01, p = .934 respectively). Picture-As-Word errors also continued to significantly predict misinformation errors (B = .189, SE = .076, F(1,173) = 6.17, p = .014) after controlling for CEQ scores.

3.4 Study 2 Discussion

In line with Specific Aim 2 (i.e. the assessment of the robustness and replicability of relationships between misinformation susceptibility and basic visual as well as verbal source monitoring errors), Study 2 replicated the findings of Study 1, showing again that relative to Word-As-Picture errors, individual differences in susceptibility towards Picture-As-Word source monitoring errors are more closely related to misinformation susceptibility. These results also extend the findings of Study 1 to show that the previously observed effect is robust under testing formats which directly contrast true and false memory traces (i.e., 2AFC versus True/False judgments). Notably, the link between Picture-As-Word errors and misinformation susceptibility in Experiment 2 was also
notably weaker (B = .32 vs. B = .11, t(258) = 2.19, p = .029). While a decrease in the number of misinformation endorsements was noted in Study 2 relative to Study 1 (MD = .39), the magnitude of this reduction seems too small to account for the drop in effect size. Thus, it is possible this shift was driven by the change in testing format though it is also possible the measurement of effect size in Study 2 is more precise given its larger sample size.

Specifically, unlike the single item true/false test, the 2AFC test in Experiment 2 involves a comparison between original and misinformation item memory traces. For instance, with regard to misinformation items, the single item true/false format targets specific narrative memory traces without directly encouraging the retrieval of the conflicting event memory detail. In contrast, misinformation endorsements on the 2AFC test represent the outcome of a more complex comparison process involving the relative weighing of the strength of visual and verbally presented information. Thus the fact that Picture-As-Word errors continue to be a significant predictor under these testing conditions lends additional support to the idea that verbalization related processes play a stronger role in the misinformation effect than visualization.

With regard to the questionnaires, the observed link between the CEQ and the NISROE inventory is interesting to note, and to the best of my knowledge, the first known demonstrated link between the measures. With regard to the purpose of Study 2 however, none of the administered measures displayed significant direct or moderating associations with the primary misinformation measures of interest. These results suggest that the observed link between Picture as Word errors and misinformation susceptibility is not driven by individual differences in visualization ability, internal versus external
information encoding preferences or fantasy proneness. Furthermore, these findings also show that the role of visualization-driven source monitoring errors in misinformation susceptibility is not stronger among individuals most likely to exhibit such a link (i.e., individuals with higher levels of mental imagery vividness, fantasy proneness, and internal information source preferences).

Study 3

4.1 Study 3: Introduction

Study 3 utilizes high-density electroencephalography (EEG) to assess differences in neural activity associated with recognition responses on both the misinformation effect and Picture-Word source monitoring paradigm. In doing so, Study 3 aims to meet Specific Aim 3 of this dissertation (i.e., to investigate potential links between neural activity associated with recollective processing in misinformation endorsements and basic visual as well as verbal source monitoring errors).

4.1.1 Introduction to EEG and target ERP components of interest in Study 3

Electroencephalography refers to the measurement of brain electrical fields via electrodes placed on the surface of the scalp. These fields arise from the electrochemical activity within neurons which, when present in a sufficiently synchronous and geometrically aligned fashion, can produce local field potentials powerful enough to be detected at the surface of the scalp (Niedermeyer et al., 2011; Nunez, 1981). The current “standard model” of EEG proposes that local field potentials and EEG represent extracellular currents arising from dendritic postsynaptic potentials in thousands to millions of cortical pyramidal cells in parallel alignment. Other neural processes such as
ion spikes (Murakami et al., 2003), glial cell activity (Amzica & Steriade, 2000) and active currents (Reimann et al.) have also been proposed to play a role in shaping ongoing EEG activity.

At a higher-order level, however, a comprehensive understanding of the specific computational neural processes which give rise to many of the well-established features of the EEG remains an unexplored area of study (Cohen, 2017). Nonetheless, while the specific mechanisms underlying many aspects of the EEG signal are not yet completely known, decades of meticulous and ongoing work on EEG has shed significant light on the functional links between specific EEG components and a wide range of cognitive processes. This growth has been especially expansive with regard to event-related potentials (ERPs), portions of the ongoing EEG waveform time-locked to the onset of a specific target event (i.e., stimulus presentations, motor responses). When averaged across multiple trials and evaluated concerning a neutral baseline, the ERP waveform consists of a series of positive and negative deflections. Decades of research has linked specific spatial topographies and associated time-windows, often referred to as ERP components, within these fluctuations with many aspects of cognitive processing. Several of these components arise consistently and predictably enough to have significant research value.

Study 3 focuses on the specific memory related ERP component most strongly associated with recollective processing, the late-positive-component (LPC). Typically taking the form of a positive ERP modulation maximal over parietal regions (ca. 500-900 ms post-stimulus onset), the Late Positive Component (LPC) has been shown to be more positive for memory test items endorsed as “remembered,” with a relatively weaker
positive deflection for memory test items endorsed as “known”. The LPC’s amplitude has also been repeatedly shown to be positively associated with the recollection of accurate source information from both a threshold (Rugg et al., 1996; Rugg et al., 1998; Vilberg et al., 2006; Wilding et al., 1995; Wilding & Rugg, 1996) and graded perspective (Leynes & Phillips, 2008; Paller et al., 1995; Wilding, 2000; Woroch & Gonsalves, 2010), mapping onto phenomenological reports of recollection-based recognition (Woodruff et al., 2006). In the context of dual-process models, the LPC is often proposed as a continuous index of recollective strength (Woroch & Gonsalves, 2010).

4.1.2 Goals of study 3

Study 3 has two primary goals. The first goal is to shed light on differences in recollective strength, as indexed by the LPC, between true and false memory endorsements on the misinformation effect in isolation. Links between the LPC and source recollection (Rugg et al., 1996; Rugg et al., 1998; Vilberg et al., 2006; Wilding et al., 1995; Wilding & Rugg, 1996) and evidence for reduced reliance on verbatim and source features (Mather et al., 1997) in false memories suggests that the LPC towards true event item endorsements will be more positive than endorsements of false misinformation-based content. Misinformation rejections made on the basis of retrieving conflicting perceptual event information are also likely to show elevated LPC levels relative to false memories, though to a weaker degree relative to true memory recognition in which the true event detail is provided as a retrieval cue. Thus with regard to this aim, it is hypothesized that true memories will exhibit an elevated LPC relative to
misinformation endorsements with misinformation rejection responses exhibiting an LPC level in-between the two.

The second goal of Study 3 is to shed light on links between the recollective responses on the Picture-Word task and misinformation endorsements. Specifically, Study 3 aims to assess the association between the LPC response in misinformation endorsements, visual recollections (Picture-As-Picture) and verbal recollections (Words-As-Word). While it would be interesting to link error responses (i.e., Picture-As-Word, Word-As-Picture) directly, the results of Study 1 and 2 indicate that participants would not make sufficient errors on the Picture-Word task to allow for reliable ERP analyses. With regard to this aim, it is hypothesized that the LPC towards misinformation endorsement will be more strongly related to verbal (Word-As-Word) source attributions as opposed to visual ones (Picture-As-Picture).

Of secondary interest in Study 3 are the responses to the Picture-Word task itself given that this relationship has already been previously studied in prior work. Drawing on this prior work, the first clear hypothesis is that items recognized as having been previously presented should show an elevated LPC relative to items categorized as being “new”. This prediction is in line with past ERP studies of the Picture-Word task (Gonsalves & Paller, 2000; Johansson et al., 2002). Again drawing on prior work in this area (Johansson et al., 2002), no significant LPC difference is anticipated to be present between Word-As-Word and Picture-As-Picture responses.
4.2 Methods

4.2.1 Power Analysis

The target sample size was estimated using empirical power simulation in SAS 9.3 (Zhao & Li, 2012) with parameters observed in data from prior ERP investigations contrasting true and false perceptual memories (Gonsalves & Paller, 2000), as well as relevant and irrelevant event item (Gamer & Berti, 2012) and word probe (Meixner & Rosenfeld, 2014), concealed information test differentiation. With these parameters, 1000 simulated datasets were simulated for ten potential target sample sizes (10 – 30 in increments of 5). This power simulation indicated that 20 participants were sufficient to achieve 75% power to detect medium within-subject sizes ($f \geq 0.25$).

4.2.2 Participants

Nineteen participants (12 female, 15 right-handed, mean age=19.84, SD =2.49, range 18-23) participated in this study. The local IRB approved all procedures with participants providing informed consent and receiving research credit for their participation. No participant attrition was noted in this study.

4.2.3 Materials

*Edinburgh Handedness Inventory*: The Edinburgh Handedness Inventory (Oldfield, 1971) was used to assess individual differences right and left-handed dominance (i.e., laterality). The inventory is a 10-point questionnaire in which participants are asked to rate their handedness preference for a range of activities by either indicating an average or a strong preference for a particular hand or equal preference. Handedness scores are
then determined by calculating a laterality quotient for each subject via the formula \((R-L)/(R+L)\) where \(R\) is the number of activities in which the right hand is preferred and \(L\) the number of activities in which the left hand is preferred.

**Picture-word source monitoring task:** The procedure of the study phase of the picture word task in Study 3 was identical to the ones used in the two prior experiments with the following modifications. First, the number of stimuli was expanded from 77 to 190 (95 pictures and 95 words) in an attempt to ensure a sufficient number of source monitoring errors for EEG analysis. Second, to boost the number of errors made further, a one-day retention interval was present between the study and test stages. Finally, to present the expanded stimuli set within a reasonable time frame, participants were asked to list one use for the item as opposed to two with all stimuli being presented on screen for 6 seconds instead of the 8 seconds utilized in Studies 1 and 2.

EEG data was only recorded during the testing phase of this task. The testing procedure, shown in Figure 1, was similar to the testing procedure used in Studies 1 and 2 save that instead of presenting the names of the objects auditorily—which would have made it more difficult to temporally localize the ERP components given variation in the acoustic presentation of the items (e.g., varying number of syllables, “Axe” versus “Magnifying Glass”)—all test items were presented visually within a 2 degree angle of All responses were made on a 4-key button box. Participants were instructed to abstain from blinking in slides A through D and permitted to blink during Slide E if necessary. Participants were tested on all 190 studied items as well as 20 new unstudied items.
Figure 1: EEG picture-word testing procedure and presentation durations.

**Misinformation effect task:** EEG data on this task was collected solely during the testing phase. The misinformation task used was similar to the one used in Studies 1 and 2 with four main changes. First, the number of events slides was expanded from two to four (Narratives 1 through 4 in Appendix B) with all events coming from Okado and Stark (2005). These separate events depicted (1) a man breaking into a car, (2) a woman’s wallet being stolen, (3) a repairman stealing office supplies and (4) two friends getting into a fight.

Second, the same procedure used in Study 1 was utilized in Study 3 with a lack of counterbalancing between event and post-event items. As in Study 1, participants were explicitly told that their memory for these events would be tested at a later point in the study. To ensure a sufficient number of trials for reliable ERP analysis, the number of critical details tested per event was expanded from 12 to 24. This expansion was done by assigning all the critical items from Study 1 to the misinformation condition and adding
12 new control items for each event. This modification meant that a full counterbalancing of the selection of items assigned to control and. Misinformation conditions between participants was not possible due to the limited number of details that varied between Version A and Version B in Okado & Stark’s (2005) materials. However, the type of misinformation participants received was counterbalanced between-participants (i.e., half the participants viewed event version A and received misinformation in line with what was shown in version B and vice versa). The use of a consistent control condition was maintained from Study 1 as referring to central items in a neutral fashion (e.g., referring to a hanger as a “tool”) or not mentioning them at would have led to differential processing of control and misled items during the misinformation phase. Not mentioning central items in the narrative at all would have led to the misled items receiving a recency study boost relative to control items. The same issue would apply even if control items were mentioned neutrally with the additional complication of potentially prompting participants to actively retrieve the specific event detail itself (e.g., reading that a “tool” was used would likely prompt participants to actively retrieve the specific memory of that specific tool), potentially creating additional cognitive operation related cues not prompted with regard to misinformation content.

Finally, the type of test was the True/False test used in Study 1 as the simultaneous presentation of items in the 2AFC would have made it difficult to disentangle the neural recollection signatures associated with each item.

Participants were tested on all 48 misinformed details (12 from each event) and, due to testing time constraints, 40 randomly selected details from the 48 consistent control items (10 from each event). The testing procedure is presented in Figure 2.
Participants were instructed to make source judgments on the basis of the recalled source they were basing their True/False evaluation on. All responses were made on a 4-key button box. A blank screen was presented for 2000 ms between each trial. Participants were instructed to abstain from blinking in slides A through D and permitted to blink during Slides E & F. Test items were blocked by event and presented in random non-chronological order within blocks. A short sentence reinstated the context of each event at the start of each block.

*Figure 2: EEG misinformation testing procedure and presentation durations.*

4.2.4 Procedure

The study consisted of five phases across two days. In the first three phases conducted on the first day, participants viewed all four events sequentially followed by
the picture-word study and misinformation narrative study phases. Participants were instructed that the goal of the study was to investigate the neural processes of event memory and provided signed informed consent. They were then briefed on the experimental procedures and were seated in individual testing rooms where they completed the misinformation event study phase (Phase 1) followed by the picture-word task study phase (Phase 2) and the misinformation narrative study phase (Phase 3). All stimuli were presented on a personal computer. At the end of this process, the participants were dismissed and reminded to return and attend the testing session on the next day.

Testing for both tasks (Phases 4 & 5) was conducted between 12 pm and 5 pm on the following day. In this session, participants first complete a standard Snellen test of visual acuity test to establish normal/corrected-normal visual acuity of at least 20/30. Participants kept on any prescription lenses/contacts they required. Each participant stood approximately 20 feet from the 22” x 11” Snellen chart. From this distance, the participant then read out letters on each line, starting from the top and going to the bottom. The experimenter stopped the vision screener when the participant incorrectly read three or more letters on a single line. Visual acuity levels were recorded as that of the line before the line in which three mistakes were made. The participant completed this procedure separately for their right and left eye.

Following this screening test, the participant was then given a refresher briefing on the purpose of the experiment and were asked to verbally reaffirm their participation consent. Upon providing consent, the electrode net was applied to the participant’s head and adjusted to ensure proper placement and sufficiently low impedances (< 45 ohms). The participant was then seated in a quiet, dark room facing a computer monitor placed
1-meter away with a 4-button button box in their hands. They then first completed the misinformation test (Phase 4) followed by the picture-word test (Phase 5). Impedances were inspected and readjusted if necessary between the two tests. Each participant was then tested individually with two experimenters monitoring the participant and real-time waveforms for ocular and movement artifacts.

4.2.5 Electrophysiological Recording

EEG data was recorded using a 256 high-density AgCl electrode Hydrocell Geodesic Sensor Net connected to a NetAmps 300 amplifier on Netstation version 4.4.2 (Electro Geodesics, Inc., Eugene, OR). Electrode impedances were below 45 kΩ, a level appropriate for the high impedance system. Impedances were inspected and adjust in between each presented task. Incoming data was analogue filtered from 0.1-100 Hz and digitized at 250 Hz.

4.2.6 EEG Data Preprocessing

First, the continuous EEG was digitally filtered using a 0.3–30 Hz Hamming windowed-sinc finite impulse response zero-phase filter with cutoff frequencies at 0.05 Hz and 30.05 Hz attenuated at -6 dB. The filtered data was then segmented to the onset of the critical item presentation (Slide D in Figure 1, above), beginning 100 ms before onset and continuous for 1000 ms onwards for the misinformation task and 1500 ms onwards for the picture-word task.

The Automatic Artifact Removal (AAR) toolbox (Delorme & Makeig, 2004; Gomez-Herrero et al., 2006) was then used to remove ocular and electromyographic
artifacts using spatial filtering and blind source separation. Bad channels were then identified and interpolated in ERP PCA Toolkit (version 2.49; Dien, 2010a). Bad channels were identified across the entire session via poor overall correlation (<0.40) between neighboring channels and identified within each segment via unusually high differences between an electrode’s average voltage and that of their neighbors (>30 µv) and/or via extreme voltage differences within electrode channels (>100 µv min to max). A channel was also marked as bad for the entire session if more than 20% of its segments were classified as being bad. All identified bad channels were replaced using whole head spline interpolation. After bad channels were identified and interpolated, trials with more than 10% interpolated channels were removed from the analysis set. Segments were then re-referenced to an average reference and baseline corrected using the 100 ms pre-stimulus average,

Regrettably, there was an insufficient number of Perceptual Control Rejections (Mean = 7.16, SD = 2.79) for reliable analysis. The average number of clean trials in the three critical categories (Control Endorsement, Control Rejection, Misinformation Endorsement, Misinformation Rejection) were, however, sufficient for analysis. The average number of trials in each condition was 13.21 (SD=4.21) in the Perceptual Misinformation Endorsement Category, 20.07 (SD = 5.20) in the Perceptual Control Endorsement Category and 16.02 (SD=4.08) in the Perceptual Misinformation Rejection category.

In the Picture-Word task, data from one participant was unfortunately lost due to a technical error. In the remaining 18 participants, the average number of clean trials in each response category were as follows: Picture-As-Picture (M = 64.67 SD = 13.98),
Picture-As-Word (M = 15.29 SD = 8.94), Picture-As-New (M = 15.00 SD = 8.94), Word-As-Picture (M = 19.29 SD = 10.89), Word-As-Word (M = 60.86 SD = 14.94), Word-As-New (M = 14.10 SD = 8.90), New-As-New (M = 15.19 SD = 3.80), New-As-Picture (M = 2.47 SD = 1.51), New-As Word (M = 3.59 SD = 2.60). Unfortunately however, nine participants performed extremely well on the task resulting in an insufficient number of errors (< 10) for analysis. As removing these participants would result in an insufficient number of subjects for reliable analyses, the decision was made to focus subsequent analyses on Picture-As-Picture, Word-As-Word, and New-As-New responses instead.

4.3 Results

4.3.1 Misinformation Effect Behavioral Results

Test performance is presented in Tables 22 through 25. Tables 22 and 23 show the breakdown of control items as a function of endorsement versus rejection and subsequent source judgment. Tables 24 and 25 present the same breakdown for misinformed items. “Seen” and “Seen & Read” responses (i.e., perceptual attributions), was the critical response category focused on in subsequent analyses.

Table 22: Study 3 Control Item Response Frequencies and Standard Deviations

<table>
<thead>
<tr>
<th>Condition</th>
<th>Seen</th>
<th>Seen &amp; Read</th>
<th>Perceptual Attribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endorsement</td>
<td>11.15 (4.52)</td>
<td>10.42 (5.32)</td>
<td><strong>21.57 (5.06)</strong></td>
</tr>
<tr>
<td>Rejection</td>
<td>5.00 (2.81)</td>
<td>2.26 (1.76)</td>
<td><strong>7.26 (2.75)</strong></td>
</tr>
</tbody>
</table>
Table 23: Study 3 Control Item Response Proportions and Standard Deviations

<table>
<thead>
<tr>
<th>Condition</th>
<th>Seen</th>
<th>Seen &amp; Read</th>
<th>Perceptual Attribution</th>
<th>Read</th>
<th>Guess</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endorsement</td>
<td>.28 (.11)</td>
<td>.26 (.13)</td>
<td><strong>.54 (.13)</strong></td>
<td>.09 (.09)</td>
<td>.09 (.07)</td>
</tr>
<tr>
<td>Rejection</td>
<td>.13 (.07)</td>
<td>.06 (.04)</td>
<td><strong>.18 (.07)</strong></td>
<td>.03 (.05)</td>
<td>.07 (.60)</td>
</tr>
</tbody>
</table>

Table 24: Study 3 Misinformed Item Response Frequencies and Standard Deviations

<table>
<thead>
<tr>
<th>Condition</th>
<th>Seen</th>
<th>Seen &amp; Read</th>
<th>Perceptual Attribution</th>
<th>Read</th>
<th>Guess</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endorsement</td>
<td>13.36 (4.16)</td>
<td>5.47 (4.15)</td>
<td><strong>18.84 (4.09)</strong></td>
<td>2.74 (2.74)</td>
<td>3.68 (3.35)</td>
</tr>
<tr>
<td>Rejection</td>
<td>7.31 (4.41)</td>
<td>6.16 (3.56)</td>
<td><strong>13.47 (4.06)</strong></td>
<td>6.68 (4.66)</td>
<td>2.58 (2.12)</td>
</tr>
</tbody>
</table>

Table 25: Study 3 Misinformed Item Response Proportions and Standard Deviations

<table>
<thead>
<tr>
<th>Condition</th>
<th>Seen</th>
<th>Seen &amp; Read</th>
<th>Perceptual Attribution</th>
<th>Read</th>
<th>Guess</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endorsement</td>
<td>.15 (.09)</td>
<td>.13 (.07)</td>
<td><strong>.28 (.08)</strong></td>
<td>.14 (.10)</td>
<td>.05 (.04)</td>
</tr>
<tr>
<td>Rejection</td>
<td>.28 (.09)</td>
<td>.11 (.09)</td>
<td><strong>.39 (.09)</strong></td>
<td>.06 (.06)</td>
<td>.08 (.07)</td>
</tr>
</tbody>
</table>

Pairwise t-tests indicated that participants made more control endorsements than misinformation endorsements with perceptual attributions (MD = 8.11, SD = 4.77, t(18) = 7.405, p < .001), a greater number of perceptual based misinformation rejections than misinformation endorsements (MD = 5.37, SD = 4.67, t(18) = 5.012, p < .001) and a
greater number of perceptual misinformation endorsements than perceptual control rejections. Intercorrelations between the primary variables of interest are presented in table 26. The full correlation matrix for all responses is presented in Appendix E. Note that, as in Study 1, correlations within the misinformation and control item groups are not completely independent as the selection of a control option on misinformed item (misinformation rejection) precludes the possibility of a misinformation endorsement for that item.

Table 26: Study 3 Correlations Misinformation Test Responses

<table>
<thead>
<tr>
<th></th>
<th>Perceptual Misled Item Endorsements</th>
<th>Perceptual Misled Item Rejections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceptual Event Item Endorsements</td>
<td>.47*</td>
<td>.47*</td>
</tr>
<tr>
<td>Perceptual Misled Item Endorsements</td>
<td>-</td>
<td>.34</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

4.3.2 Picture Word Behavioral Data

Response proportions on the Picture-Word test task are presented in Tables 27 and 28. Pairwise t-tests indicated that participants were more likely to correctly attribute items shown as words as being presented as words relative to misattributing them as having been pictures (MD = 43.50, SD = 20.42, t(17) = 9.04, p <.001) or unpresented items (MD = 46.50, SD = 21.21, t(17) = 9.30, p =<.001). Participants were also more likely to correctly attribute items shown as pictures as being presented as pictures relative to misattributing them as having been words (MD = 47.27, SD = 21.52, t(17) = 9.32, p
<.001) or unpresented items (MD = 47.72, SD = 20.48, t(17) = 9.88, p =<.001).

Participants also more frequently correctly categorized unpresented items as “new” relative to misattributing them as having been originally presented as pictures (MD = 14.22, SD = 3.38, t(17) = 17.81, p < .001) or words (MD = 13.11, SD = 4.87, t(17) = 11.41, p <.001). Finally, participants were marginally more likely to misattribute new items as having being presented as words relative to pictures (MD = 1.11, SD = 2.29, t(17) = 2.05, p = .056).

Table 27: Study 3 Picture Word Task Response Frequencies and Standard Deviations

<table>
<thead>
<tr>
<th>Response</th>
<th>Shown As</th>
<th>Picture</th>
<th>Word</th>
<th>New</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Picture</td>
<td>63.33 (13.32)</td>
<td>16.05 (9.69)</td>
<td>15.61 (8.91)</td>
</tr>
<tr>
<td></td>
<td>Word</td>
<td>18.17 (9.68)</td>
<td>61.67 (12.93)</td>
<td>15.17 (9.68)</td>
</tr>
<tr>
<td></td>
<td>Not-Shown</td>
<td>1.56 (1.04)</td>
<td>2.67 (2.28)</td>
<td>15.78 (2.69)</td>
</tr>
</tbody>
</table>

Table 28: Study 3 Picture Word Task: Response Proportions and Standard Deviations

<table>
<thead>
<tr>
<th>Response</th>
<th>Shown As</th>
<th>Picture</th>
<th>Word</th>
<th>New</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Picture</td>
<td>.67 (.14)</td>
<td>.17 (.10)</td>
<td>.16 (.09)</td>
</tr>
<tr>
<td></td>
<td>Word</td>
<td>.19 (.10)</td>
<td>.65 (.14)</td>
<td>.16 (.11)</td>
</tr>
<tr>
<td></td>
<td>Not-Shown</td>
<td>.08 (.05)</td>
<td>.13 (.11)</td>
<td>.79 (.13)</td>
</tr>
</tbody>
</table>
4.3.3 Misinformation and Picture-Word Behavioral Links

While an apriori power analysis indicated that the projected number of participants in the EEG study would not have sufficient power (>80%) to detect the effects observed in Studies 1 and 2, an exploratory analysis was conducted to assess the direction of the previously detected effects in Experiment 3. A single linear random intercept model with robust standard errors was used to model the predictive relationship between misinformation susceptibility (DV) and “Picture-As-Word” (IV1) as well as “Word-As-Picture” (IV2) source monitoring errors. The results of this analysis showed that Word-As-Picture errors were not significantly related with misinformation susceptibility, $B = .116$, $SE = .095$, $F(1,15) = 1.48$, $p = .243$, while a greater number of picture as word errors were marginally related to higher levels of perceptual misinformation susceptibility, $B = .175$, $SE = .095$, $F(1,15) = 3.34$, $p = .088$. Neither Word-As-Picture or Picture-As-Word errors were significant predictors of perceptual control item endorsement levels ($B = -.139$, $SE = .129$, $F(1,15) = 1.17$, $p = .297$, and $B = -.042$, $SE = 129$, $F(1,16) = .11$, $p = .749$ respectively).

4.4 ERP Analyses

4.4.1 Temporal-spatial Analyses of Misinformation task ERPs

ERP components were quantified using temporal-spatial PCA in ERP PCA Toolkit. First, a temporal PCA was performed on the data using all time points from each participant’s averaged ERP as variables, considering participants, condition and recording sites as observations. This step reduced the temporal structure of the ERP data (275 measurement points) to a set of temporal components. Promax rotation was used,
and nineteen temporal components (92% of total variance) were extracted based on parallel analysis (Horn, 1965).

The spatial distribution of these components was then decomposed using spatial PCA. This PCA used all recording sites as variables, considering participants, conditions and temporal factor scores as observations. This step reduced the electrode structure (257-channels) to a set of virtual electrodes on which the original electrodes loaded. Infomax rotation was used, and six spatial components (72% of total variance) were extracted based on parallel analysis.

Standardized Low-Resolution Brain Electromagnetic Tomography (sLORETA; Pascual-Marqui et al., 1994) was used to estimate the standardized distribution of current density of the grand-average waveform (averaged across all response conditions) during the peak time point of all components. The significance threshold was estimated using a statistical non-parametric mapped permutation test (Nichols & Holmes, 2002), utilizing 10000 randomizations of 6430 voxels (3-shell spherical head model, 5 mm resolution) with subject-wise normalization.

Selection of the LPC component was conducted in a two-step process. First, components that accounted for at least 40 ms of temporal-spatial variance were identified. Three components met this criterion, a posterior positivity with a peak timespan (component temporal loadings > 0.8) 288-416 ms post-onset (4.2% of total variance), a posterior positivity peaking 444-616 ms post-onset (6.7% of total variance), and a weak late positivity spanning 772-900 ms post-onset onset (4.2% of total variance). Based on their time-course and topography in light of prior P3b (see Polich, 2007 for a review) and LPC work (Curran et al., 2001), the first component (288-416 ms) was
classified as the P3b whereas the second was classified as an LPC (444-616 ms). Given the memory related focus of this dissertation, the LPC component will be the focus of all subsequent analyses.

The source localization of the LPC component supported its classification. Activity in this component localized to the left parahippocampal gyrus, a region associated with LPC activity (e.g. Hoppstädter et al., 2015; Klaver et al., 2005) and episodic memory retrieval (see Wais, 2008 for a review) as well as true and false item memory differentiation (Cabeza et al., 2001; von Zerssen et al., 2001). Critically, both these regions have been previously implicated in differentiating between response categories in the misinformation effect paradigm (Stark et al., 2010). The time course and scalp topographies of these components are shown in Figure 3 while the grand average waveforms for electrodes with high loadings on the components are shown in Figure 4.

Figure 3: LPC component waveforms at its highest loading electrode, scalp topographies by condition and the sLORETA solution at the component’s peak time-point.
Figure 4: Average waveforms by condition for electrodes with high loadings (> 0.80) on the LPC component (marked on the electrode map). High loading (> 0.80) time points on the component are shaded on the waveform plot.

4.4.2 Misinformation Task LPC Analyses

The LPC component peak (i.e., PCA waveform voltage at the highest loading temporal-spatial point) voltage means and standard errors for responses on the misinformation task are presented in Table 29.

Table 29: Study 3 Misinformation Task LPC Component Mean Voltages and Standard Errors

<table>
<thead>
<tr>
<th></th>
<th>LPC Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Endorsement</td>
<td>1.97 µV (.52)</td>
</tr>
<tr>
<td>Misinfo. Rejection</td>
<td>.84 µV (.53)</td>
</tr>
<tr>
<td>Misinfo. Endorsement</td>
<td>-.45 µV (.90)</td>
</tr>
</tbody>
</table>
A one-way repeated measures ANOVA was conducted to contrast LPC scores across conditions. As the assumption of sphericity was not met $\chi^2 = 10.21, df = 2, p = .006$, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .689$). The ANOVA indicated LPC voltages were significantly different across conditions, $F(1.38, 24.80) = 4.08, p = .043, \eta^2_p = .185$. Follow-up pairwise comparisons showed Control Endorsements had a higher mean LPC voltage than both Misinformation Endorsements (MD = 2.42 µV, SE = 1.03 µV, $t(18) = 2.34, p = .031, d = .775$) and Rejections (MD = 1.12 µV, SE = .51 µV, $t(18) = 2.22, p = .040, d = .502$). The difference between Misinformation Endorsements and Rejections was not statistically significant (MD = 1.30 µV, SE = .91 µV, $t(18) = 1.43, p = .172, d = .404$).

4.4.3 Temporal-spatial Analyses of the Picture-Word Task ERPs

The same procedure applied to the misinformation task ERPs were also applied to the Picture-Word task ERPs to extract the underlying component structure. First, a temporal PCA was performed on the data using all time points from each participant’s averaged ERP as variables, considering participants, condition and recording sites as observations. This step reduced the temporal structure of the ERP data (375 measurement points) to a set of temporal components. Promax rotation was used, and twenty-two temporal components (94% of total variance) were extracted based on parallel analysis (Horn, 1965).

The spatial distribution of these components was then decomposed using spatial PCA. This PCA used all recording sites as variables, considering participants, conditions and temporal factor scores as observations. This step reduced the electrode structure
(257-channels) to a set of virtual electrodes on which the original electrodes loaded on.
Infomax rotation was used, and five spatial components (71% of total variance) were
extracted based on parallel analysis.

Selection of the LPC component was conducted in a two-step process. First,
components that accounted for at least 40 ms of temporal-spatial variance were
identified. Two components met this criterion, a posterior positivity with a peak timespan
(component temporal loadings > .8) 624-922 ms post-onset (7.1% of total variance) and a
frontal positivity peaking 1200-1500 ms post-onset (6.1% of total variance). Based on
their time-course and topography in light of prior cued source monitoring related LPC
work (Addante et al., 2012; Cui et al., 2016), the first component (624-922 ms) was
classified as an LPC. The topography of the second component was exclusively focused
in ocular regions, an observation supported by the bilateral source localization of this
component to the frontal eyefields. Based on these observations, the second component
was classified as being artifactual and was not considered in subsequent analyses.

Standardized Low-Resolution Brain Electromagnetic Tomography (sLORETA;
Pascual-Marqui et al., 1994) was used to estimate the standardized distribution of current
density of the grand-average waveform (averaged across all response conditions) during
the peak time point of the LPC component. The significance threshold was estimated
using a statistical non-parametric mapped permutation test (Nichols & Holmes, 2002),
utilizing 10000 randomizations of 6430 voxels (3-shell spherical head model, 5 mm
resolution) with subject-wise normalization.

The source localization of these components supported the classifications of the
observed LPC. As shown in figure 5, activity in his component peaked in bilaterally in
the right and left temporal lobes, possibly reflecting activity associated with the retrieval of memory traces in this task (Kennepohl et al., 2007; Mitchell & Johnson, 2009). The time course and scalp topographies of these components are shown in Figure 5 while the grand average waveforms for electrodes with high loadings on the components are shown in Figure 6.

4.4.4 Picture-word ERP analyses

The LPC component peak (i.e., PCA waveform voltage at the highest loading temporal-spatial point) voltage means and standard errors for analyzable responses on the Picture-Word task are presented in Table 3.

![Figure 5: LPC component waveforms at its highest loading electrode, scalp topographies by condition and the sLORETA solution at the component’s peak time-point.](image)
Figure 6: Average waveforms by condition for electrodes with high loadings (> 0.70) on the LPC component (marked on the electrode map). High loading (> 0.80) time points on the component are shaded on the waveform plot.

Table 30: Study 3 Picture-Word Task LPC Component Mean Voltages and Standard Errors

<table>
<thead>
<tr>
<th>Condition</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picture-As-Picture</td>
<td>1.84 µV (.91)</td>
</tr>
<tr>
<td>Word-As-Word</td>
<td>2.27 µV (.62)</td>
</tr>
<tr>
<td>New-As-New</td>
<td>1.41 µV (.70)</td>
</tr>
</tbody>
</table>

A one-way repeated measures ANOVA was conducted to contrast LPC scores (presented in table 30) across conditions. The assumption of sphericity was met $\chi^2=2.41$, $df=2$, $p = .300$. The ANOVA indicated LPC voltages were significantly different across conditions, $F(2, 34) = 3.56, p = .039, \eta^2_p = .173$. Follow-up pairwise comparisons showed Word as Word responses had a higher mean LPC voltages than
New as New responses (MD = 1.21 µV, SE = 1.59 µV, t(17) = 3.23 p = .005) but were not significantly different from Picture as Picture responses (MD = .43 µV, SE = 2.23 µV, t(18) = .82, p = .43). LPC voltage differences between Picture as Picture and New as New responses were also not significantly different (MD = .78 µV, SE = 1.96 µV, t(17) = 1.68, p = .112).

4.4.5 Picture-Word & Misinformation Performance ERP Links

Correlations between LPC responses on the misinformation effect and picture-word task are presented in Table 31. Given that the LPC from both tasks were measured from the same participants, it is not surprising to note that all the measures show a moderate degree of association. However, as hypothesized, verbal recollection response on the Picture-Word task exhibited relatively higher zero-order correlations with misinformation endorsement LPC levels relative to the LPC observed in other misinformation task responses.

Table 31: Study 3 Picture-Word and Misinformation LPC correlations

<table>
<thead>
<tr>
<th></th>
<th>Perceptual Misled Item Endorsement LPC</th>
<th>Perceptual Misled Item Rejection LPC</th>
<th>Perceptual Event Item Endorsement LPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picture-As-Picture LPC</td>
<td>.38</td>
<td>.44</td>
<td>.46</td>
</tr>
<tr>
<td>Word-As-Word LPC</td>
<td>.67**</td>
<td>.48*</td>
<td>.40</td>
</tr>
<tr>
<td>New-As-New LPC</td>
<td>.32</td>
<td>.34</td>
<td>.44</td>
</tr>
</tbody>
</table>

* Corrected correlation is significant at the 0.05 level (2-tailed).
** Corrected correlation is significant at the 0.01 level (2-tailed).
To empirically assess the uniqueness of the association between the LPC waveforms observed with perceptual misinformation endorsements and Word-As-Word responses, a series of linear regression models were conducted in which Picture-As-Picture and Word-As-Word LPC responses were entered simultaneously with one of the Misinformation task LPCs as the target dependent variable. Results showed that Misinformation Endorsement LPC levels were positively related only to Word-As-Word LPC levels (semipartial correlation = .64, B = 1.62, SE = .44, t(15) = 3.72, p = .002) and marginally negatively related to Picture-As-Picture (semipartial correlation = -.32, B = -.55, SE = .32, t(15) = 1.87, p = .081). After controlling for their shared variance, Picture-As-Picture and Word-As-Word LPC responses were not significantly related to either Control Endorsement (semipartial correlation = .23, B = .25, SE = .34, t(15) = 1.03, p = .319 and semipartial correlation = .02, B = .04, SE = .37, t(14) = 1.03, p = .919 respectively) or Misinformation Rejection LPC levels (semipartial correlation = .09, B = .10, SE = .24, t(15) = .39, p = .903 and semipartial correlation = .19, B = .31, SE = .36, t(15) = .837, p = .416 respectively). The zero order correlation scatterplots are presented in Figures 7 through 9).
Figure 7: Plot of perceptual misinformation endorsement LPC voltages versus LPC voltage for (A) Word as Word, (B) Picture as Picture and (C) New as New responses on the Picture-Word source monitoring task.
Figure 8: Plot of perceptual control item endorsement LPC voltages versus LPC voltage for (A) Word as Word, (B) Picture as Picture and (C) New as New responses on the Picture-Word source monitoring task.
Figure 9: Plot of perceptual misinformation rejection LPC voltages versus LPC voltage for (A) Word as Word, (B) Picture as Picture and (C) New as New responses on the Picture-Word source monitoring task.

4.5 Study 3: Discussion

In line with Specific Aim 3 (i.e. the investigation of potential links between neural activity associated with recollective processing in misinformation endorsements and basic visual as well as verbal source monitoring errors), Study 3 assessed links between the LPC response, an ERP component associated with recollective processing and strength, towards false memory endorsements on the misinformation effect and accurate verbal as well as visual source attributions on a Picture-Word source monitoring task. The results of study 3 show that the LPC associated with false memory endorsements on the misinformation effect was more strongly related to accurate verbal as opposed to
visual memory attributions responses on the picture-word monitoring task. In other words, individual differences in the strength of their recollective responses during false memory endorsement were more strongly related to the strength of their recollective response when they made accurate verbal memory attributions as opposed to visual ones. This result lends support to the idea that individual differences in misinformation susceptibility are more strongly related to verbalization relative to visualization based processing, providing additional support for the results of Study 1 and Study 2.

In addition to this finding, Study 3 also makes several other important direct contributions to research on the misinformation effect. Of particular value, this investigation represents the first EEG investigation of the misinformation effect aimed at investigating retrieval processes that differentiate between event and misinformation-based memories. To the best of my knowledge, Study 3 is also the first investigation of recollective differences between true versus false recognition of episodic details embedded in their narrative context. In this regard, the findings of Study 3 indicate that false memory endorsements on the misinformation effect are associated with a significantly weaker recollective signature relative to true memory endorsements. This result is consistent with extensive work that has linked greater positivity in the LPC with superior source monitoring performance (Leynes & Phillips, 2008; Paller et al., 1995; Rugg et al., 1996; Rugg et al., 1998; Vilberg et al., 2006; Wilding, 2000; Wilding et al., 1995; Wilding & Rugg, 1996; Woroch & Gonsalves, 2010). There are however two distinct accounts for this observed effect.

The first is that relative to the narrative study of the misinformation details, perceptual exposure provides true event memories with a stronger perceptual and
verbatim memory traces. Thus, the observed LPC difference between true versus false memories observed in Study 3 may be reflective of perceptual memory trace strength differences between true relative to false perceptual memories (Brainerd et al., 2008; Gonsalves & Paller, 2000; Mather et al., 1997). The second complementary factor resides in the type of control being used to assess “true” memories. All control items in this study were “consistent controls” (i.e., test items that were consistent with both the event and the narrative), a type of control commonly used in many misinformation effect investigations (e.g. Calvillo, 2014; Wang et al., 2014; Zhu et al., 2013; Zhu, Chen, Loftus, Lin, He, Chen, Li, Moyzis, et al., 2010). Thus, it is possible that part of the observed LPC differences between control and misinformation items may be due to participants being exposed to control items twice (once in the event and once in the narrative) but only being exposed to the misinformation items once (in the narrative). Building on these findings by contrasting the memory signature of consistent versus pure control (i.e., test items consistent with the event and mentioned neutrally in the narrative) items would represent an important contribution to the field given the largely interchangeable use of these types of control items in the literature.

Fortunately, this limitation does not directly impact the link between misinformation endorsement and Word-As-Word LPCs observed in this study. Drawing on this demonstrated link between verbal processing and misinformation endorsements at test, the next logical step is to move towards assessing the links between verbal processing and misinformation as well as event encoding on the misinformation effect paradigm. The final experiment in this dissertation, Study 4, was developed to achieve this goal.
5.1 Study 4: Introduction

Study 4 examines the relationship between individual differences in misinformation susceptibility and oscillatory neural activity during the event as well as narrative encoding stages of the misinformation effect paradigm. In doing so, the present study aims to achieve Specific Aim 4 (i.e., to investigate potential links between neural activity associated with event and narrative encoding on the misinformation effect and misinformation susceptibility). As opposed to a local approach in which responses to specific items are conditionalized on subsequent behavioral responses (e.g., Study 3), a global approach is adopted in which encoding activity associated with all the event images and narrative sentences is analyzed collectively for each subject, based on the consistency with event items (i.e., consistent vs. inconsistent) independent of subsequent behavioral responses. The logic of this approach is that individual differences in processing orientation during encoding which are predictive of misinformation susceptibility are likely to be present throughout the entire encoding process. Adopting this approach resolves the issue of low trial numbers present in Study 3 by including all items in the analytic model, substantially improving the signal-to-noise ratio in all target categories.

A full discussion of prior neuroimaging work on the misinformation effect is presented in section 1.6. Of primary relevance, prior work by Okado and Stark (2005) and Baym and Gonsalves (2010) utilized fMRI to investigate event and misinformation encoding activity on the misinformation effect paradigm. However, Okado and Stark (2005) utilized the unorthodox approach of presenting both the event and misinformation visually making it difficult to link their findings to the standard visual event followed by
verbal misinformation design. As a result, the primary relevant study in this area comes from Baym and Gonsalves (2010), who utilized a standard misinformation effect design in their investigation. The primary result of interest in their findings with regard to the focus of Study 4 was the observed directionally greater activity in BA45 (left insula/inferior frontal gyrus), a neural region associated with semantic processing (Keller et al., 2009; Novick et al., 2009; Oh et al., 2014) and verbal retrieval (Heim et al., 2009), in false relative to foil memories.

This finding from Baym and Gonsalves (2010)’s work lays the foundation for the present investigation. A key difference between the current study and Baym and Gonsalves (2010)’s work is the use of EEG as opposed to fMRI. While fMRI imaging has many advantages with regard to localization specificity, the method still faces considerable challenges with regard to temporal resolution. Of particular relevance to this investigation, the relatively slow and indirect Blood-Oxygen-Level Dependent (BOLD) contrast imaging fMRI approach utilized in Baym and Gonsalves (2010) does not allow neural activity to be decomposed into its constituent neural frequencies. The phrase neural frequencies refer to the presence of voltage oscillations in the ongoing EEG which are associated with a wide range of cognitive, perceptual, emotional and motor processes (Cheung et al., 2014; Griffiths et al., 2016; Gulbinaite et al., 2014; Imperatori et al., 2014; Lansbergen et al., 2011; Vandenbroucke et al., 2015). The most frequently assessed frequencies are denoted using Greek letters such as the Delta, Theta, Alpha, Beta, Gamma and Mu frequencies. Most of these frequencies are remarkably quick. Theta, for instance, a relatively “slow” rhythm in the 4-8 Hz range is still almost an order of magnitude faster than most fMRI scanning protocols can capture. Given that BOLD
fMRI typically records one data-point every 1-2 seconds, fMRI simply cannot decompose the dynamics of these frequencies.

Shedding light on the dynamics of these neural frequencies is important for several reasons. Firstly, neural frequencies have the potential to be a common language for disparate disciplines within the field of neuroscience. These oscillations are studied in detailed computational models, in vitro single-cell work, implanted electrode investigations and of course scalp based EEG and magnetoencephalography. There is even evidence to suggest that fMRI is also primarily driven by perturbations in neural frequency related activity, albeit indirectly (Engell et al., 2012). Furthermore, through the use of high-density arrays and cutting edge source localization methods, it is also possible to estimate the neural generators of these observed rhythms, an approach which has significant potential to boost the discipline bridging value of frequency based analyses.

The primary target frequency band of interest in this experiment is the theta (4 – 8 Hz) band as increased activity in this range has been consistently associated with encoding and consolidation related activity (Duzel et al., 2010; Griffiths et al., 2016; Hanslmayr et al., 2011; Schneider & Rose, 2016; Staudigl & Hanslmayr, 2013), likely playing a key role in event-context binding (Fell & Axmacher, 2011; Summerfield & Mangels, 2005). The primary goals of Study 4 with regard to encoding activity are to:

1) Assess links between neural activity during the visual event encoding phase and individual differences in misinformation susceptibility. In this study, misinformation susceptibility levels were quantified as the number of misinformation endorsements given a perceptual source attribution. Participants were divided into low and high misinformation susceptibility groups using a
median-split approach as the analytic techniques utilized in this study could not accommodate continuous variables in the modeling process.

2) Assess links between individual differences in neural activity during the verbal narrative encoding and individual differences in misinformation susceptibility.

The primary hypotheses for the first goal are that (1) activity in low-level visual or higher-level visual associated regions will not be associated with misinformation susceptibility and (2) increased activity in regions associated with semantic and verbal processing will be significantly related to misinformation susceptibility. The primary hypothesis for the second goal is that increased activity in regions associated with semantic and verbal processing in all three statement types (indicative of global differences in modality processing) will be significantly related to misinformation susceptibility levels. Drawing on the work of Baym and Gonsalves (2010), the primary target area of interest with regard to verbal and semantic processing is the left inferior frontal region. In addition to these two primary goals, a secondary set of hypotheses for Study 4 is that given the more direct link between misinformation item encoding and subsequent endorsement, this relationship will be stronger for misinformation items relative to consistent control items within participants.

With regard to test items, as the use of full item counterbalancing in this study resulted in too few misinformation endorsements to differentiate responses as a function of response, neural responses during the retrieval (i.e., test) phase were analyzed in a global fashion collapsing across response type (i.e. endorsement versus rejection) within the control and misled item categories. The sole prior investigation of retrieval activity on the misinformation effect was conducted by Stark et al. (2010) using visually presented
events and auditorily presented verbal misinformation. Stark et al. (2010) found that misinformation-based false memories were associated with activity in regions associated with auditory and language processing (BA22 & 42; see (Buchsbaum et al., 2001; Chan et al., 2014; Leff et al., 2009; Moseley et al., 2014). In line with these findings, the primary hypothesis for this phase is that, as per the encoding stage, (1) activity in low-level visual or higher-level visual associated regions will not be associated with misinformation susceptibility and (2) increased activity in regions associated with semantic and verbal processing will be significantly related to misinformation susceptibility levels. A secondary test stage focused hypothesis is that given the more direct link between misinformation item responses and their endorsement, the relationship between misinformation susceptibility levels and semantic and verbal processing related neural response towards misinformation items at test will be stronger relative to the response to consistent control items.

5.2 Methods

5.2.1 Power Analysis

While the bootstrapped driven permutation based analyses for frequency power analyses preclude precise calculations of projected power (particularly given the yet untested empirical relationship between trial numbers and the reliability of localized spectral activity related analyses), significance thresholds estimated from my prior work utilizing this technique with significantly fewer trials (Kiat et al., 2018) suggests the target sample size of 30 participants is large enough to detect relationships > r = 0.50 (post p-value correction), between oscillatory activity target voxels and misinformation
susceptibility levels, considerably larger than the effect sizes typically noted in use of localized cross-spectrum analyses (Imperatori et al., 2015; Imperatori et al., 2013; Meltzer et al., 2009; Shao et al., 2012; Yun et al., 2012). The target sample size of 30 in this study is also notably larger than the samples used in most published investigations utilizing analytic techniques similar to those employed in this study (14 participants: Imperatori et al., 2013; 16 participants: Meltzer et al., 2009; 20 participants: Yun et al., 2012).

5.2.2 Participants

Thirty participants (17 female, 29 right-handed, mean age=19.70, SD =2.18, range 17-28) participated in this study. All participants were recruited from the UNL Psychology Department subject pool via an online research participation platform (SONA). The University’s IRB approved all procedures with participants providing informed consent and receiving 2.0 hours of research credit for their participation. Four participants were subsequently removed from the analysis due to excessive EEG artifacts, leaving a final sample of 26 participants. Two of these participants had hairstyles which prevented the EEG electrodes from maintaining good contact, despite the use of hairnets. Two of these participants had dry eye issues which led to excessive levels of ocular and EMG related artifacts.

5.2.3 Materials

*Encoding Focused Misinformation EEG task:* A modified version of the EEG-suitable misinformation effect task used in Study 3 was employed in this investigation. As in
Study 3, a total of four events were presented with participants being explicitly told that their memory for these events would be tested at a later point in the study. Each event was first presented in 50 event slides followed by 50 narrative slides. Each narrative slide contained one sentence with only one critical item per sentence. A total of 12 critical details were selected from each event, 6 of which were assigned to the control condition and 6 to the misled condition for a total of 24 control and 24 misled items. Participants were tested on all 24 control and 24 misled items at test.

Instead of the partial counterbalancing procedure used in Study 3, the full counterbalancing procedure used in Study 2 was utilized with consistent controls. This counterbalancing strategy proceeded as follows. Two different event versions of each event were used (i.e., version A and version B). Across these two versions, critical event details from 12 slides were different. Half of those details were randomly assigned to group X whereas the other half were assigned to group Y. Item groups X and Y were assigned to either the control or misinformation conditions creating four combination conditions for each presented scenario. Table 3 presents the procedure for a single scenario. Items assigned to the misled condition in each combination (i.e., Set 1A) were described inaccurately in the narrative in a manner matching how they were presented in the other event version (e.g., version 1B) whereas control items were described in a manner consistent in the narrative (consistent control).

The same counterbalancing structure utilized in Study 2 was utilized in Study 4, reproduced here for convenient reference. In this approach, version A presented a man breaking into a car with a hanger and finding cocaine whereas version B presented a man breaking into a car with a credit card and finding marijuana. The object used to break into
the car and what was found were then assigned to item group X and Y respectively. In example, Set 1A would present the man breaking into a car with a hanger and finding cocaine with the narrative reading “He used a credit card to open the car door” and “He pulled out a bag of drugs”; Set 2A would present the man breaking into a car with a hanger and finding cocaine with the narrative “He used a tool to open the car door” and “He pulled out a bag of marijuana.”; Set 1B would present a man breaking into a car with a card and finding marijuana with the narrative reading “He used a hanger to open the car door” and “He pulled out a bag of drugs”; Set 2B would present a man breaking into a car with a card and finding marijuana with the narrative reading He used a tool to open the car door” and “He pulled out a bag of cocaine”.

Table 32: Study 4 Counterbalancing Strategy

<table>
<thead>
<tr>
<th>Event Version</th>
<th>Misinformed Items</th>
<th>Consistent Control Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viewed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set 1A</td>
<td>A</td>
<td>Group X</td>
</tr>
<tr>
<td>Set 2A</td>
<td>A</td>
<td>Group Y</td>
</tr>
<tr>
<td>Set 1B</td>
<td>B</td>
<td>Group X</td>
</tr>
<tr>
<td>Set 2B</td>
<td>B</td>
<td>Group Y</td>
</tr>
</tbody>
</table>

Another modification to the study phase, implemented to ensure a sufficiently long baseline period for effective frequency related analysis, was the extensions of the interstimulus interval to 1000 ms from the original 500 ms time-window.
Auditory Oddball Paradigm: This task was utilized as a filler task to ensure a reasonable retention interval between the misinformation narrative study and testing phases. In this task, participants were presented with 1000 Hz (frequent) and 2000 Hz (infrequent) 350 ms tones with a 1000 – 1500 ms pseudo-randomly varied interstimulus interval. All tones were presented at 60 dB SPL as measured at the subject’s ear. 40 frequent and 320 infrequent trials (20:80 frequent: infrequent presentation ratio) will be presented. Participants were asked to silently count the number of infrequent responses (Debener et al., 2005) to minimize the influence of non-detection related muscle responses. The results of this task were not linked with the misinformation analyses.

DRM Association Response Task: This task was utilized as a filler task to ensure a reasonable retention interval between the misinformation event and narrative study phases. In this task, participants were presented with 72 five-item DRM drawn from the norms of Stadler et al. (1999). The presentation of each list will begin with a central fixation (+) presented for 1000 ms followed by a blank screen for 1000 ms; five associates presented one at a time for 1000 ms each with a 1000 ms blank screen interval between associates. In 36 of the lists, the strongest associate (i.e., what would usually have been the critical lure in the list) will be presented as the 2\textsuperscript{nd} word whereas, in the remaining 36, the associate will be presented as the 5\textsuperscript{th} word in the list. The results of this task will not be linked with the analyses in this dissertation.
5.3 Procedure

5.3.1 Experiment Procedure

All participants were tested individually. In each test session, the participant was first briefed on the purpose of the experiment and verbally guided through the informed consent form. Upon providing informed consent, participants completed a brief demographics measure after which the electrode net was applied to the participant’s head and adjusted to ensure proper placement and sufficiently low impedances (< 45 ohms). After the adjustment process, 3 minutes of open-eye resting state data were collected (3 minutes). Participants then completed the misinformation event study phase (10 minutes) followed by an auditory oddball filler task (10 minutes). Upon completion of this task, net impedances were inspected and adjusted as needed (5-10 minutes). Participants then completed the misinformation narrative study phase (10 minutes). After reading through all narratives, participants completed the DRM filler task (10 minutes). This task was then followed by a final impedance adjustment (5-10 minutes) and the misinformation paradigm test (20 minutes). The entire session took a maximum of 2 hours to complete.

5.3.2 Electrophysiological Recording

EEG data was recorded using a 256 high-density AgCl electrode Hydrocel Geodesic Sensor Net connected to a NetAmps 300 amplifier on Netstation version 4.4.2 (Electro Geodesics, Inc., Eugene, OR). Electrode impedances were below 45 kΩ, a level appropriate for the high impedance system. Impedences were inspected and adjusted in between each presented task. Incoming data was analogue filtered from 0.1-100 Hz and digitized at 1000 Hz.
5.3.3 EEG Preprocessing

EEG data were analyzed using custom MATLAB scripts and the EEGLAB toolbox (Delorme & Makeig, 2004). First, the continuous EEG was digitally filtered using a 0.1–30 Hz Hamming windowed-sinc finite impulse response zero-phase filter with cutoff frequencies at 0.05 Hz and 30.05 Hz attenuated at -6 dB. The continuous filtered data was then downsampled to 250 Hz and cleaned using the following procedure. First flat line (duration threshold = 5 seconds) and noisy (line noise relative to signal > 4 standard deviations above the total channel population) channels as well as channels with poor correlations with their neighbors (r < 0.85) were removed. Noisy segments were then cleaned using the Artifact Subspace Reconstruction adaptive based spatial filtering approach (Kothe & Makeig, 2013; Mullen et al., 2015). The ASR filter operates by first identifying and applying Principal Component Analysis based decomposition to clean portions of data and then identifying segments of the data with signal components that deviate significantly (> 5 standard deviations) from the calibration data. These bad segments are then corrected using the mixing matrix computed from the clean data segment. After this procedure was completed, the initially removed channels were spherically interpolated via whole head spline interpolation in EEGLab. The preprocessed data was then submitted to an extended infomax ICA (Bell & Sejnowski, 1995; Lee et al., 1999) using the runica function (Makeig et al., 1996) from the EEGLab toolbox with each subject being processed individually. Given that estimating a number of components equal to the number of recording channels (256) would be both computationally prohibitive and empirically questionable, the dimensionality of the data
was first reduced to 128 components via PCA before being submitted to the ICA procedure.

The goal of the application of ICA is to derive independent sources from highly correlated data (in this case, ongoing EEG) statistically using a source blind approach (i.e., an approach that disregards spatial locations and source generator configurations). This goal is accomplished by estimating a matrix (i.e., the “unmixing” matrix/vector) that when applied to the data vector linearly transform the vector into a set of independent (i.e., zero mutual information) elements (i.e., components). This effectively assumed that the EEG data \( V \) (a channels by \( t \) time matrix) is composed of a set of independent components \( M \) (a components \( k \) by time \( t \) matrix) such that \( M = W^{-1}V \) where \( W^{-1} \) is a matrix consisting of \( k \) by \( c \) weights (the unmixing matrix).

This method differs from decorrelation based procedures such as principal components analysis (PCA) which instead strive to ensure the cross-products (i.e., correlation) between components is zero. PCA does not perform as well with regard to extracting non-orthogonal spatially overlapping sources (Delorme & Makeig, 2004; Dien, 2010b; Dien et al., 2007; Richards, 2004), characteristic of the scalp level EEG signal. Furthermore, as the PCA approach strives to maximize the amount of variance each successively extracted component accounts for that is uncorrelated with previously determined components, the method often summates activity from multiple independent sources making it less suitable for isolating maximally independent sources (Delorme & Makeig, 2004).

The ICA approach is suited for performing source separation in domains in which sources are independent, sum linearly at the scalp with minimal propagation delays, and
that the number of independent signals does not exceed the number of sensors (Delorme et al., 2007; Makeig et al., 1996). These assumptions are considered hold true for EEG derived data (Delorme et al., 2007; Makeig et al., 1996).

The rationale behind utilizing ICA to “un-mix” the EEG signal draws on research showing that, in line with theoretical models of the generation of EEG components, the behavior of ICA identified temporally independent sources are significantly more bipolar (i.e., dipole-like) than the raw EEG signal (Delorme et al., 2012). This step is important as virtually all EEG source localization procedures rely on estimating a number of equivalent current dipoles (or estimating activity across multiple dipole moments in gray matter voxel space (Pascual-Marqui, 2002)) whose summed projections to the scalp best reproduces observed scalp-level activity (Cohen, 2017). Unmixing the signal at the scalp level is thus both theoretically in line with the generation model of EEG and empirically in line with the projection model underlying dipole based source localization procedures.

Drawing on this empirical background, after the EEG data was preprocessed and decomposed using ICA, the equivalent current dipole model for each derived ICA component was computed using a non-custom realistically shaped boundary element model (BEM) in the DIPFIT toolbox. This procedure was applied to each participant individually using an average reference montage. The use of realistically shaped BEMs has been shown to significantly improve the accuracy of EEG source localization relative to less realistic sphere based procedures (Vanrumste et al., 2001; Vanrumste et al., 2002; Vatta et al., 2010).

The data was then segmented to the onset of each event image or sentence presentation, beginning 1000 ms before onset and continuous for 3500 ms thereafter.
Epochs with abnormal spectral profiles (>50 or < -50 dB threshold across the 1-30 Hz band) were then identified and rejected using EEGLab’s spectra rejection functions. Finally, the retained events were classified based on their trial type (control event, misinformation event, noncritical event).

This procedure was applied to both the visual and narrative event data. With regard to the visual event data, each participant retained an average of 162.96 visual event study trials (SD = 5.10, Range = 152-169) comprised of 20.54 control event (SD = 1.86, Range = 15-23), 20.19 misinformation event (SD. = 2.17, Range = 15-125) and 122 noncritical event trials (SD = 5.28, Range = 111-129). With regard to the narrative data, each participant retained an average of 165.00 narrative sentence study trials (SD = 5.37, Range = 155-175) comprised of 20.08 control sentences (SD = 1.60, Range = 16-23), 19.96 misinformation sentences (SD. = 2.05, Range = 17-24) and 124.96 noncritical sentence trials (SD = 5.39, Range = 114-135). Finally, with regard to the test stage, each participant retained an average of 22.07 control (SD = 1.21, Range = 19-24) and 22.18 misinformation (SD. = 1.70, Range = 15-24) target item responses.

5.3.4 Analytic Strategy

Combining information from multiple participants and conditions, each associated with their own set of source processes and scalp projections, across complex EEG measures in source space presents considerable challenges. Contrasting 3D source locations and dynamics as opposed to equating scalp channel locations across participants (a potentially problematic approach in itself) is an analytic approach that has only recently begun to be applied to EEG related data.
One of the more well-known methods in this area is standardized low-resolution brain electromagnetic tomography (sLORETA) (Pascual-Marquès, 2002). The sLORETA approach standardizes the current density estimates given by the minimum norm inverse solution first developed by Hämäläinen and Ilmoniemi (1994). The sLORETA approach divides the brain space into a fixed number of voxels, each of which possesses a set of dipole moments which are estimated by the technique (Pascual-Marquès, 2002). Given the fixed number of voxels, source current dipole moments can then be compared across conditions via estimating significance thresholds via statistical non parametric mapping based non-parametric permutation tests (Patihis et al., 2013).

The sLORETA approach is powerful and is widely used. Indeed, the original analytic strategy of this study was to decompose scalp-recorded oscillatory activity during encoding trials and localize that activity into frequency bands using standardized low-resolution brain electromagnetic tomography (sLORETA). The Talairach coordinates of the electrode positions of the EGI Hydrocel system would be used to compute the sLORETA transformation matrix used to estimate the current density of underlying cortical generators.

Despite the widespread use of sLORETA, there are some limitations involving the use of the technique. One of the most pressing limitations is the current restrictions with regard to the application of baseline activity normalization methods in frequency space with the sLORETA method. In the context of EEG frequency-based analyses, baseline normalization refers to the use of procedures which recharacterize event-
related changes in power as deviations with respect to a particular baseline as opposed to their original unnormalized form.

Baseline subtraction is highly recommend for frequency based EEG analysis given that (1) the distribution of EEG time-frequency power data follows a $1/f$ power law function which makes it difficult to make quantitative comparisons of power across frequency bands, (2) individual and session specific differences make it difficult to aggregate effects across participants, and (3) task-related changes in power can otherwise be difficult to disentangle from background activity. While the sLORETA approach allows for baseline activity subtraction via subtracting the total band frequency power data from the data, thereby resolving some of these issues, it cannot currently implement time-window baseline based correction. This limitation raises a key interpretive issue.

Without time-window based baseline normalization, it is impossible to determine if observed differences in spectral activity are driven by inherent differences between participants or task-related. For example, assume that participants with inherently higher levels of frontal alpha activity also happen to be less susceptible to false memories but that higher frontal alpha on a specific task response had no impact on task performance. Without correcting for inherent individual differences via normalization, one can easily be led into interpreting higher levels of task-related alpha as being reflective of the engagement of memory-related neural processes.

The solution to this issue is to apply pretrial based baseline normalization to the trial level data in which time-frequency activity in a pretrial baseline is effectively used to establish a baseline to which critical trial related activity can be contrasted.
with. Among several analytic advantages such as the converting power results into a common interpretable metric (i.e., change in power relative to baseline), time-window baseline normalization transforms power data across multiple frequencies to the same scale and disentangles time-frequency related dynamics from subject-specific factors. Returning to the earlier frontal alpha – false memory example, applying pretrial baseline normalization to the trial level data ensures that the trial related changes in neural frequency power represent changes beyond a participant’s baseline state.

To implement this procedure while still assessing individual differences in EEG frequency activity in source space, the Measure Project Analysis (MPA) method was utilized. The MPA technique is an elegant general approach for estimating and statistically contrasting source-resolved EEG measures recently developed by Bigdely-Shamlo et al. (2013). The MPA method resolves the problem of comparing EEG source localization and dynamics across participants and conditions in source space by adopting a novel probabilistic approach. Following the decomposition of the EEG data via ICA into independent components to which source equivalent dipoles were estimated (see section), the EEG measure of interest in all derived components are probabilistically represented within a cubic dipole source grid with 8-mm spacing (3908 vertices) in MNI space. This projection process is accomplished by representing each dipole in that space as a 3D Gaussian distribution centered at the estimated dipole location with a standard error of 12 mm extending outwards for three standard deviations. This projected representation of the component is referred to as the “projected measure”. The local convergence (i.e., similarity matrix) between the projected measure vectors is then calculated with a significance threshold for
convergence values obtained via permutation of the similarity matrix which removes the correspondence between each IC and its associated measure, representing the null hypothesis of no stable association between region and measure. Finally, voxels with significant convergence values are clustered into domains using a threshold-based affinity propagation clustering method (Frey & Dueck, 2007) which, using the matrix of pairwise correlations between projected measure values at each voxel, iteratively determines an appropriate number of domain clusters.

The MPA procedure was applied to both the visual event study, narrative study and test response datasets. The projected measure of interest was the frequency power of the projected components within the event and narrative study time-windows (3500 ms). Frequency power was estimated using a Fast-Fourier transform (Cooley & Tukey, 1965) spectral decomposition focused on the 1 – 20 Hz range with a 1000 ms pre-stimulus baseline. A time-frequency based decomposition approach was not utilized given significant variation in sentence length and the position of the critical item within them. Activity in higher frequencies was not assessed as to reduce contamination from electromyographic activity induced by the free-viewing conditions of the task. A group-wise p < .0125 threshold corrected using False Discovery Rate (FDR) testing which gave a raw voxel significance threshold of p ≤ .0045 (event) and p ≤ .001 (text) for the visual event and narrative datasets respectively.
5.4 Results

5.4.1 Misinformation Effect Behavioral Data

Test performance is presented in Tables 33 through 36. Tables 33 and 34 show the breakdown of control items as a function of endorsement versus rejection and subsequent source judgment. Tables 35 and 36 present the same breakdown for misinformed items. “Seen” and “Seen & Read” responses (i.e., perceptual attributions), was the critical response category focused on in subsequent analyses.

Table 33: Study 4 Event Item Response Frequencies and Standard Deviations

<table>
<thead>
<tr>
<th>Condition</th>
<th>Seen</th>
<th>Seen &amp; Read</th>
<th>Perceptual Attribution</th>
<th>Read</th>
<th>Guess</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endorsement</td>
<td>2.60 (3.68)</td>
<td>12.27 (5.32)</td>
<td>14.87 (2.60)</td>
<td>3.17 (2.18)</td>
<td>1.43 (1.48)</td>
</tr>
<tr>
<td>Rejection</td>
<td>1.50 (1.80)</td>
<td>1.00 (1.02)</td>
<td>2.50 (1.74)</td>
<td>.73 (.83)</td>
<td>1.30 (1.34)</td>
</tr>
</tbody>
</table>

Table 34: Study 4 Event Item Response Proportions and Standard Deviations

<table>
<thead>
<tr>
<th>Condition</th>
<th>Seen</th>
<th>Seen &amp; Read</th>
<th>Perceptual Attribution</th>
<th>Read</th>
<th>Guess</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endorsement</td>
<td>.11 (.15)</td>
<td>.51 (.18)</td>
<td>.62 (.11)</td>
<td>.13 (.09)</td>
<td>.06 (.06)</td>
</tr>
<tr>
<td>Rejection</td>
<td>.06 (.07)</td>
<td>.04 (.04)</td>
<td>.10 (.07)</td>
<td>.03 (.03)</td>
<td>.05 (.06)</td>
</tr>
</tbody>
</table>
**Table 35: Study 4 Misled Item Response Frequencies and Standard Deviations**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Seen</th>
<th>Seen &amp; Read</th>
<th>Perceptual Attrib</th>
<th>Read</th>
<th>Guess</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Endorsement</strong></td>
<td>5.93 (.75)</td>
<td>2.17 (2.03)</td>
<td><strong>8.10 (3.80)</strong></td>
<td>.87 (1.36)</td>
<td>1.30 (1.29)</td>
</tr>
<tr>
<td><strong>Rejection</strong></td>
<td>1.60 (2.13)</td>
<td>4.77 (3.51)</td>
<td><strong>6.37 (3.47)</strong></td>
<td>5.93 (3.37)</td>
<td>1.43 (1.17)</td>
</tr>
</tbody>
</table>

**Table 36: Study 4 Misled Item Response Proportions and Standard Deviations**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Seen</th>
<th>Seen &amp; Read</th>
<th>Perceptual Attrib</th>
<th>Read</th>
<th>Guess</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Endorsement</strong></td>
<td>.25 (.20)</td>
<td>.09 (.08)</td>
<td><strong>.34 (.16)</strong></td>
<td>.04 (.06)</td>
<td>.05 (.05)</td>
</tr>
<tr>
<td><strong>Rejection</strong></td>
<td>.07 (.09)</td>
<td>.20 (.14)</td>
<td><strong>.27 (.15)</strong></td>
<td>.25 (.14)</td>
<td>.06 (.05)</td>
</tr>
</tbody>
</table>

Pairwise t-tests indicated that participants made more control endorsements than misinformation endorsements with perceptual attributions (MD = 6.77, SD = 3.85, t(29) = 9.63, p < .001) and more perceptual misinformation endorsements than perceptual control rejections (MD = 5.60, SD = 3.88, t(29) = 7.90, p < .001) with the difference between perceptual based misinformation rejections and misinformation endorsements being not statistically different from zero (MD = 1.73, SD = 6.01, t(29) = 1.581, p = .125). Intercorrelations between the primary variables of interest are presented in table 37. The full correlation matrix for all responses is presented in Appendix F. Note that, as in Study 1, correlations within the misinformation and control item groups are not completely independent as an endorsed control or misinformation item cannot also be rejected.
To form low and high misinformation susceptibility groups for subsequent analyses, participants were divided into two groups using a median split approach ($\bar{x} = 9$) on the obtained perceptual misled item endorsement scores. This division was implemented as the methods utilized in this study, in line with many advanced EEG procedures, could not accommodate continuous variables in the modeling process.

**Table 37: Study 4 Correlations Misinformation Test Responses**

<table>
<thead>
<tr>
<th></th>
<th>Perceptual Misled Item Endorsements</th>
<th>Perceptual Misled Item Rejections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceptual Event Item Endorsements</td>
<td>.32</td>
<td>.17</td>
</tr>
<tr>
<td>Perceptual Misled Item Endorsements</td>
<td>-</td>
<td>-.36</td>
</tr>
</tbody>
</table>

5.4.2 Measure Projection Analysis Results: Event Study Phase

Given the free-viewing conditions of the event study phase in which participants were allowed to blink and move their eyes, prior to analysis the possibility of a noise confound between misinformation and control conditions was first assessed. If present, this would indicate a differential level of artifacts between conditions which could potentially drive apparent differences in derived frequency activity between them. This possibility was assessed using a procedure first proposed by Schimmel (1967) in which the polarity of every other trial was first inverted. Inverted and un-inverted trials were then re-averaged so that consistent ERP signals canceled out, leaving a noise estimate of overall noise levels (quantified via the average absolute voltage value left post-averaging) assuming an equivalent number of inputted trials. The results of this analysis showed that
there were no significant differences in noise between control and misinformation event items, \( t(1,25) = .96, p = .364 \). Furthermore, differences in noise levels between control and misinformation event was not significantly related to individual differences in subsequent levels of misinformation (all \( p \)'s > .13) or control item endorsement levels (all \( p \)'s > .44).

Figure 10 shows the frequency profile and significant voxels for the measure-consistent IC domains for projected EEG frequency activity during the event study phase (\( p \leq .0045 \); group-wise \( p < .0125 \) under FDR). These results indicate the engagement

1) A posterior brain domain which localized to the posterior cingulate cortex (BA31, BA30) and secondary as well as associative visual cortex (BA18, BA19)

2) A central domain which localized to the posterior medial cortex and posterior cingulate cortex [BA31, BA23] and precuneus [BA7])

3) A bilateral frontal domain localized in prefrontal (BA10, BA46, BA9) and dorsal anterior cingulate (BA32) regions.

The statistical significance of observed frequency differences between slide responses as a function of individual differences in misinformation susceptibility was assessed using permutation-based t-test comparison corrected for multiple comparisons using False Discovery Rate with an alpha of .05. The toolboxes utilized to conduct these analyses currently do not provide specific inferential statistics for specific observations but instead provide significant thresholds which are used to assess the “significance level” of those values. Utilizing this analytic approach, none of these domains showed significant differences in engagement between slides containing
details that were assigned to the control condition versus slides with details that were assigned to the misinformation condition.

Figure 10: Event-related Measure Projection Analysis results. (A) Brain domains revealed by MPA analysis of EEG frequency activity during the event study phase. (B-D) Plots of grand average power spectral densities by event slide type within (B) Domain 1 (C) Domain 2 (D) Domain 3.

As shown in Figure 11, significant differences in activity were observed in domain 3 as a function of individual differences in misinformation susceptibility across several frequency domains for all slide types. Specifically, significantly higher levels of theta and alpha activity (specific frequency values highlighted in gray in Figures 11C-D), extending to the low beta range was noted in this domain for all slide types among
participants with higher levels of misinformation susceptibility (defined in this study as making a number of perceptual misinformation endorsements above the sample median of $\tilde{x} = 9$). None of the other domains showed significant differences as a function of participant type in any of the misinformation task response conditions.

Figure 11: Measure Projection Analysis results for event domain 3. (A) Significance contrasts between participants with low versus high susceptibility to misinformation in the MPA derived event domain 3 (BA10, BA46, BA9, and BA32). (B-C) Plots of grand average power spectral densities by misinformation susceptibility levels for (B) misinformation and (C) control and (D) non-critical event slides.
5.4.3 Measure Projection Analysis Results: Narrative Study Phase

As was done for the event study response, the possibility of a noise confound between neural responses during the narrative study phase was first assessed prior to conducting the MPA procedure. The results of this analysis showed that there were no significant differences in noise levels between the control and misinformation sentence study trials, \( t(1,25) = .93, p = .364 \). Furthermore, differences in noise levels between control and misinformation sentence study trials was not significantly related to individual differences in subsequent levels of misinformation (all \( p \)'s > .24) or control item endorsement levels (all \( p \)'s > .34).

Figure 12 shows the frequency profile and significant voxels for the measure-consistent IC domains for projected EEG frequency activity during the narrative study phase (\( p \leq .001 \); group-wise \( p < .025 \) under FDR). These results indicate the engagement of:

1) A posterior brain domain which localized to the posterior cingulate cortex (BA31, BA30) and secondary visual cortex (BA18)

2) A left frontal domain which localized to the left anterior prefrontal (BA10), orbitofrontal (BA11), dorsolateral prefrontal (BA46) and inferior frontal (BA47) regions.

None of these domains showed significant differences in activity between slides containing details that were consistent with the control condition versus slides with details that were consistent with the misinformation condition.
Figure 12: Narrative related Measure Projection Analysis results. (A) Brain domains revealed by MPA analysis of EEG frequency activity during the narrative study phase. (B-C) Plots of grand average power spectral densities by event slide type within (B) Domain 1 and (C) Domain 2.

As shown in Figure 13, significant differences in activity were observed in domain 2 as a function of individual differences in misinformation susceptibility across several frequency domains for all slide types. Specifically, significantly higher levels of theta activity registered during the processing of misinformation containing slides among participants who subsequently expressed higher levels of misinformation susceptibility. Participants with higher misinformation susceptibility levels also showed significantly higher levels of low Beta level activity in this domain during the processing of non-
critical slides. This effect was also directionally present in the other conditions but did not achieve significance. None of the other domains showed significant differences as a function of participant type in any of the misinformation task response conditions.

Figure 13: Measure Projection Analysis results for narrative domain 2. (A) Significance contrasts between participants with low versus high susceptibility to misinformation in the MPA derived narrative domain 2 (BA31, BA23, and BA7). (B-C) Plots of grand average power spectral densities by misinformation susceptibility levels for (B) misinformation and (C) control and (D) non-critical event slides.
5.4.4 Measure Projection Analysis Results: Test Phase

As was done for the event study response, the possibility of a noise confound between neural responses during the narrative study phase was first assessed prior to conducting the MPA procedure. The results of this analysis showed that there were no significant differences in noise between control and misinformation event items, $t(1.25) = .69, p = .497$. Furthermore, differences in noise levels between control and misinformation event was not significantly related to individual differences in subsequent levels of misinformation (all $p$’s $> .35$) or control item endorsement levels (all $p$’s $> .65$).

Figure 14 shows the frequency profile and significant voxels for the measure-consistent IC domains for projected EEG frequency activity during the test phase ($p \leq .0015$; group-wise $p < .0125$ under FDR). These results indicate the engagement of a

1) A posterior brain domain which localized to the posterior cingulate cortex (BA31, BA30, BA23).
2) A left lateralized central region which localized to anterior (BA24) and posterior cingulate cortex (BA23, BA31).
3) A left frontal domain which localized to the left anterior prefrontal (BA10), orbitofrontal (BA11), and inferior frontal (BA47) regions.
4) A right lateralized temporal domain which localized to superior (BA22), middle (BA21), and anterior transverse temporal (BA41, BA42) gyri.

None of these domains exhibited significant differences in engagement between control test items versus misinformation-based test items across the full study sample. Furthermore, none of these domains showed significant differences in engagement as a function of individual differences in misinformation susceptibility for the processing
of either control or misinformation test items. Note that these analyses collapse endorsement and rejection responses and thus do not provide information regarding differences between control endorsement and misinformation rejection responses.

Figure 14: Measure Projection Analysis results. (A) Brain domains revealed by MPA analysis of EEG frequency activity during the test phase. (B-E) Plots of grand average power spectral densities by event slide type within (B) Domain 1 (C) Domain 2 (D) Domain 3, (E) Domain 4.
5.5 Study 4: Discussion

In line with Specific Aim 4 (i.e., the investigation of potential links between neural activity associated with event and narrative encoding on the misinformation effect and misinformation susceptibility), Study 4 assessed links between individual differences in oscillatory neural activity during the event and narrative encoding stages with regard to misinformation effect susceptibility. Drawing on the findings of Study 1, Study 2, Study 3 and prior work by Baym and Gonsalves (2010), the primary hypotheses of Study 4 were that (1) misinformation susceptibility would not be associated with increased activity in low-level visual or higher-level visual associated regions and (2) misinformation susceptibility would be associated with increased activity in regions associated with semantic processing and verbal retrieval. The primary frequency of interest in all hypotheses was activity in the theta range. The same hypotheses were proposed to apply to the event, narrative and test stages of the misinformation effect.

The secondary hypotheses of this study was that the relationship between misinformation susceptibility and activation in regions associated with semantic processing as well verbal retrieval would be stronger for misinformation items relative to control items. Again, the same hypotheses were proposed to apply to the event, narrative and test stages of the misinformation effect paradigm.

5.5.1 Study 4 Event and Narrative Phase Results

To assess the level of support for these hypotheses with regard to the study phases, the general domain results (i.e., MPA results excluding the role of misinformation susceptibility) will first be discussed. The findings highlight neural frequency domains
which show coherent patterns of activity during encoding on the misinformation effects
across all participants and trial types. Tentatively, these results indicate that these
domains play a role in encoding episodic information presented in a visual and verbal
form.

In both study phases, significant activity was noted in a posterior domain which
localized to regions in the posterior cingulate and secondary visual cortex. The posterior
cingulate is often implicated in episodic memory formation (Huijbers et al., 2012; Kim et
al., 2010; Lega et al., 2017; Papma et al., 2017) and some aspects of source memory
(Uncapher et al., 2006). Most likely activity in this region was associated with general
attention-related processes during encoding (Cabeza et al., 2008), an observation which
would be in line with recent work linking misinformation susceptibility with individual
differences in attentional processing (Kiat, 2018). This interpretation gains additional
support from the observation that activity in this area was higher related to activity in the
secondary visual cortex, a region associated with the encoding of both words (Ragland et
al., 2004) and pictures (Menard et al., 1996).

During visual encoding, coherent frequency activity was also noted in a domain
which localized to the precuneus. This point is interesting in the context of this
dissertation as activity in the precuneus is often linked with mental imagery (Fletcher et
al., 1995; Zhang & Li, 2012). Of particular relevance, activity in the precuneus during
encoding of words has repeatedly been shown to be significantly associated with the
likelihood of those words being subsequently misattributed to a visual source (Gonsalves
et al., 2004; Stephan-Otto et al., 2017). Collectively, this body of research suggests that
precuneus was playing some role associated with imagery focused encoding of the
presented event. Notably, this domain did not present itself as a significant source of coherent activity during the verbal narrative study phase.

In the visual encoding phase, coherent activity was noted in a bilateral frontal domain encompassing prefrontal and dorsal anterior cingulate regions during visual encoding. Activity in prefrontal regions has long been associated with source monitoring related processes during both the encoding and retrieval phases (Mitchell & Johnson, 2009; Ranganath et al., 2000). While still an active area of research, there is considerable support for the view that activity in these regions plays a key role in implemental top-down control processes associated with selectively enhancing the representation of goal-relevant information for subsequent transfer to long-term memory (Blumenfeld & Ranganath, 2007; Simons & Spiers, 2003). Prior work by Okado & Stark (2005) has also linked activity in left-lateralized medial frontal regions during event encoding on the misinformation effect with both true and false memory endorsement levels, speculatively suggesting that memories with a stronger semantic/verbal base may be more vulnerable to subsequent distortion. Nonetheless, given the myriad of functions the prefrontal region subserves, it is impossible to definitively isolate the specific factors driving this observed activity.

Similar activity was also noted in a left-lateralized domain encompassing anterior prefrontal, inferior frontal and orbitofrontal regions during verbal encoding. In line with the observed coherent activity during the event study phase (Blumenfeld & Ranganath, 2007; Simons & Spiers, 2003), it is likely that this activity was associated with similar top-down control related processes linked with encoding the presented information. In contrast to the visual encoding stage, however, this domain was left lateralized during the
verbal encoding phase. This observation is interesting as activity in the left ventromedial prefrontal cortex has been shown to be selectively associated with the encoding of verbal semantic stimuli, with activity in the right ventromedial prefrontal cortex being associated with visual encoding (Prendergast et al., 2013). While admittedly highly speculative, this notion suggests that encoding during the narrative study phase was primarily verbal while the visual study phase (which exhibited a bilateral profile) may have been exemplified by a combination of verbal and visual encoding processes. It is also intriguing to note that activity in the left prefrontal region has been associated specifically with increased levels of associative verbal encoding (Kim, 2011; Kirwan et al., 2008), supporting the idea that the observed activity may be associated with elaborative verbal processing.

Moving next to discuss the role of individual and trial type conditions on the abovementioned general patterns of activation, it is in these frontal domains that we see significant differences between individuals as a function of misinformation susceptibility. During visual encoding, increased levels of activity in the theta and alpha range were noted in this domain among individuals who subsequently exhibited higher levels of misinformation susceptibility. Prefrontal theta activity is frequently proposed to play an important role in supporting memory integration via bidirectional interactions with medial temporal lobe regions (Anderson et al., 2010; Backus, Schoffelen, Szebenyi, et al., 2016; Nyhus & Curran, 2010), with some researchers proposing the activity to reflect the integration of prior knowledge in new memory formation (Backus, Schoffelen, Szebényi, et al., 2016); which is intriguing given work involving the role of narrative construction in the misinformation effect.
The role of the observed increased alpha and low beta activity in this domain in individuals with higher levels of misinformation susceptibility during visual encoding is, however, less clear, particularly given the absence of hypotheses involving activity in this range. Speculatively, relative increases in alpha activity is often associated with reduced attention (Babiloni et al., 2004; Dockree et al., 2004; Pfurtscheller & Lopes da Silva, 1999) and reduced inhibition of task-irrelevant information (Chen & Huang, 2015) while higher levels of beta activity has been linked with increased memory load levels (Chen & Huang, 2015; Deiber et al., 2007). Given these links, it is possible that the combined increase in activity in the alpha and beta range reflects increased encoding difficulty among individuals with higher levels of misinformation susceptibility driven by less efficient working memory-related processes. This account would be in line with research linking misinformation susceptibility with reduced working memory capacity (Bi et al., 2010; Jaschinski & Wentura, 2002). This hypothesis is however speculative and requires significant levels of additional work before it can be seriously considered.

During the narrative encoding phase, significantly higher levels of theta activity for misinformation responses as well as increased beta activity for true responses was noted in a left-lateralized frontal domain as a function of heightened misinformation susceptibility. As discussed earlier, increased frontal theta activity is associated with memory integration related processes (Anderson et al., 2010; Backus, Schoffelen, Szebenyi, et al., 2016; Nyhus & Curran, 2010) and the integration of prior knowledge in new memory formation (Backus, Schoffelen, Szebényi, et al., 2016). Collectively this body of work suggests that individuals with higher levels of misinformation susceptibility display increased levels of encoding-related activity associated with the integration of
prior experiences (possibly reflective of narrative construction) during the encoding of the misinformation related items. Activity in the left prefrontal region has been associated specifically with increased levels of controlled semantic processes during associative verbal encoding (Kim, 2011; Kirwan et al., 2008) lending additional support to this interpretation.

The significant increase in beta activity for noncritical items is less easy to interpret. Given that this condition has the largest number of trials, it would be questionable to evaluate this result by contrasting it with its apparent absence in the other conditions. Speculatively, drawing again on research linking higher levels of beta activity with working memory load (Chen & Huang, 2015; Deiber et al., 2007), this increased activity may be reflective of a generally less efficient working memory among individuals with higher levels of misinformation susceptibility (Bi et al., 2010; Jaschinski & Wentura, 2002). Again this hypothesis is speculative and requires additional investigation before being considered seriously.

Overall, these results provide general support for the hypotheses of this study related to the encoding stages. The hypothesis that activity in low-level visual or higher-level visual associated regions during event and narrative encoding would not be associated with misinformation susceptibility was supported, though appropriate caution on the potential of insufficient power driving this should be noted. While general activity in visual processing related regions was observed during both the event and narrative study phases, in line with the visual presentation of materials, this activity was not significantly predictive of misinformation susceptibility.
The hypothesis of event and narrative encoding activity in regions (specifically the left inferior frontal gyrus) associated with semantic and verbal processing being significantly related to misinformation susceptibility was also supported. Of primary interest, increased levels of memory integration related activity in left inferior frontal regions were observed among individuals with heightened levels of misinformation susceptibility during the encoding of verbally presented misinformation. Increased activity in frontal regions, including left inferior frontal regions, was also observed among these misinformation susceptible individuals during visual encoding, though this activity was more bilaterally distributed.

5.5.2 Study 4: Misinformation Testing Phase Results

To assess the level of support for these hypotheses with regard to the testing stage, the general domain results (i.e., MPA results excluding the role of misinformation susceptibility) will first be discussed. The findings highlight neural frequency domains which show coherent patterns of activity during testing on the misinformation effect paradigm across all participants and trial types. Tentatively, these results indicate that these domains play a role in retrieving and evaluating episodic information.

During the testing phase, as in both the event and narrative study phases, coherent frequency activity noted in posterior domains which localized to the cingulate cortex. Activity in this region is, consistent with its links to episodic memory formation (Huijbers et al., 2012; Kim et al., 2010; Lega et al., 2017; Papma et al., 2017), also frequently implicated in episodic memory retrieval (Düzel et al., 1999; Rugg & Vilberg, 2013) and source recollection (Duarte et al., 2011; Frithsen & Miller, 2014; Hayama et
For the most part, activity in the posterior cingulate at test is viewed as being associated with general content-independent recollective processing (Hayama et al., 2012; Rugg & Vilberg, 2013).

Coherent activity during the testing stage was also noted in a frontal left-lateralized domain with significant overlap with the frontal domain observed during the narrative study phase. In line with its role in verbal encoding, activity in left frontal regions is frequently implicated in the retrieval of semantic/verbal retrieval (Düzel et al., 1999; Incisa della Rocchetta & Milner, 1993; Thompson-Schill et al., 1997) and processing (Gabrieli et al., 1998). Activity in the left frontal regions is also associated with general cognitive control mechanisms (Badre & Wagner, 2007b; Hirshorn & Thompson-Schill, 2006; Kramer et al., 2005) which are also likely to be implicated in memory retrieval on the misinformation effect.

Finally, coherent activity during testing was also noted in a right-lateralized temporal domain which localized to superior (BA22), middle (BA21), and anterior transverse temporal (BA41, BA42) gyri. Activity in right temporal regions has been previously noted in the context of episodic sentence recognition (Tulving et al., 1994) and word (Gernsbacher & Kaschak, 2003) and sentence processing in general (Friederici et al., 2003). The lateralization is however somewhat unexpected as left-lateralized regions are more frequently implicated in this processing domain (Friederici et al., 2003). One factor which may have driven this shift is this investigation’s use of a sentence completion style presentation which may have resulted in sentence generation related processing at test. Prior work by Kircher et al. (2001) found that right temporal regions are more strongly associated with the
generation of words to complete sentence stems. Kircher et al. (2001) propose this shift in the typical left-lateralization of language processing reflects the processing and resolution of context ambiguity. This notion would be in line with work showing a right lateralization in language processing associated with complex sentence processing (Bookheimer, 2002; Bottini et al., 1994; Cooke et al., 2002; Kircher et al., 2001; Mashal et al., 2005; Rapp et al., 2004; Virtue et al., 2006).

With regard to individual and response condition hypotheses during the testing phase, only the hypothesis that activity in low-level visual or higher-level visual associated regions would not be associated with individual differences in misinformation susceptibility levels was supported though again, appropriate caution on the potential of insufficient power driving this should be noted. Coherent activity in visual regions was not noted during this phase across all participants. The hypotheses of activity in regions associated with semantic and verbal processing being significantly related to misinformation susceptibility levels during the testing phase, on the other hand, were not supported. While general activity in domains associated with verbal and semantic processing was noted in this phase, this activity was not predictive of subsequent misinformation susceptibility.

These results can be interpreted in several ways. First, given the fact that endorsement and rejection responses were collapsed due to insufficient critical trials, it may be that individual differences in misinformation susceptibility are driven by processes specific to misinformation endorsement related responses. It is also possible that differences in endorsement and rejection related effects cancel out at the global level. For instance, merging a perceptual misinformation rejection response (associated
with the recollection of conflicting memory traces from the event phase) and perceptual misinformation endorsement response (associated with recollecting memory traces from the narrative phase), leads to an outcome that is a mixture of both. Given that misinformation rejections are more frequent; it is perhaps not surprising that overall misinformation item condition closely resembles the control item one. Finally, it is also possible that encoding processes play a more important role in driving individual differences in misinformation susceptibility relative to retrieval processing. Additional work that differentiates endorsement and rejection responses is needed, however, before this hypothesis can be considered seriously.

General Discussion

This dissertation presented four studies that investigate links between visual/verbal source monitoring and false memory susceptibility on the misinformation effect paradigm.

In Study 1, participants completed the misinformation task paradigm developed by (Okado & Stark, 2005) and were tested using a true/false memory test. They also completed a picture-word source monitoring task and several personality inventories (The CEQ, MC-SDS, and DES). The results of this study showed that individual differences in misinformation susceptibility were significantly related to individual differences in susceptibility towards making visual-to-verbal source monitoring errors (i.e., Picture-As-Word) and not significantly related to verbal-to-visual source monitoring ones (i.e., Word-As-Picture). These results were also shown to be independent of individual differences in the inclination towards engaging in imagination/fantasy related activities, having dissociative experiences and desires for being view in a socially positive manner.
These findings provided evidence to support the hypothesis of misinformation endorsements being more closely related to verbalization or narrative driven source monitoring errors as opposed to visualization based ones.

In Study 2, participants again completed the misinformation paradigm administered in Study 1 but were tested using a 2AFC memory test this time around. Participants also completed the same picture-word source monitoring task utilized in Study 1 as well as several personality inventories (the Creative Experiences Questionnaire, the Internal/External Encoding Style Questionnaire, and the Visualizer-Verbalizer Questionnaire). The findings of Study 2 replicated the results of Study 1. Once again individual differences in misinformation susceptibility were significantly related to individual differences in susceptibility towards making visual-to-verbal source monitoring errors (i.e., Picture-As-Word) and not significantly related to verbal-to-visual source monitoring ones (i.e., Word-As-Picture). Importantly, these results were shown to be independent of individual differences in visualization ability and preferences towards internal versus external sources of encoding related information.

In Study 3, participants again completed the misinformation paradigm and picture-word task utilized in the prior two studies. This time around, the study and test phases was separated by a 1-day retrieval interval with EEG data being recorded during the testing phase of both tasks. The EEG component of interest in this investigation was the LPC, an ERP component strongly associated with recollective strength. The results of this study showed a strong and significant link between recollection linked neural activity associated with misinformation endorsements and recollection activity associated with verbal memory endorsement on the picture-word source monitoring task.
In Study 4, participants completed the misinformation paradigm while EEG data were recorded during the study and testing phase. This time around, the design compromises made to the task in Study 3 were removed to allow for full counterbalancing control of the materials. While this precluded a retesting of the effects observed in Study 3 due to signal-to-noise issues posed by insufficient critical trial numbers, the primary focus of Study 4 was not to replicate those findings but to instead link individual differences in encoding related neural activity during the event and narrative study phases with individual differences in misinformation susceptibility. Drawing on the findings of Studies 1 through 3, the primary hypothesis of Study 4 was that encoding-related activity in neural regions associated with semantic/verbal processing would be elevated among individuals with higher levels of misinformation susceptibility during the event, narrative, and testing phases. The results of Study 4 were partially in support of this a stronger role in predicting misinformation susceptibility in such a design.

Collectively, the results of Studies 1 through 4 suggest that individual differences in the tendency to draw on verbal/semantic processes play an important role in driving false memory susceptibility in the misinformation effect paradigm. These findings are in line with research indicating that individual differences in visualization based processing ability (Cann & Katz, 2005; Desjarlais & Bernstein, 2012; Greening, 2002; Nichols & Holmes, 2002; Pérez-Mata & Diges, 2007; Tomes & Katz, 1997) and preferences (Tomes & Katz, 1997; Tousignant, 1984) have a relatively weak relationship to false memory susceptibility on the misinformation effect. Instead, these results lend weight to research indicating that verbalization and semantic-based processes have a stronger relationship
with misinformation effect susceptibility (Baym & Gonsalves, 2010; Lee, 2004; Nori et al., 2014; Schooler et al., 1986; Tomes & Katz, 1997; Tousignant et al., 1986; Zaragoza et al., 2011).

These findings are intriguing as, on the surface, they run counter to a long-running trend in false memory research that considers visualization and mental imagery to play a key role in false-memory endorsements on the misinformation effect. However, as discussed extensively in the introduction section of this paper, the evidence in support of this point is considerably weaker than one would expect with considerably more evidence in support of the role of verbalization\semantic-based processing.

It is particularly interesting to consider these findings in the context of the source monitoring framework (Johnson & Raye, 1981; Johnson et al., 1977), coexistence hypothesis (Belli, 1989; Johnson et al., 1993; Lindsay & Johnson, 1987), and theoretical work linking the SMF and misinformation effect susceptibility (Dodhia & Metcalfe, 1999; Hekkanen & McEvoy, 2002; Lindsay & Johnson, 1989a; Zaragoza & Lane, 1994). To illustrate this integration, Figure 15 presents a potentially useful model in which to position these observed findings. Figure 15 shows a simplified diagram of the formation of true and misinformation based memory traces with memory traces marked by hexagons and their constituent source feature traces marked in squares, with the size of each square indicating the hypothetical strength of the enclosed feature. In this framework, the primary difference between true and misinformation based memory traces are elevated visual feature strength in true memories as well as elevated semantic and temporal (due to the relative recency of the narrative information) feature strength in misinformation memories. In addition to its evident links to the source monitoring
framework, this model can also be viewed from a memory impairment perspective, specifically in light of the coexistence hypothesis (Belli, 1989; Johnson et al., 1993; Lindsay & Johnson, 1987) in which both the original event and misleading information are proposed to co-exist in memory. From this angle, increased preferences for verbal\semantic processes would elevate both the initial encoding strength as well as the likelihood and/or strength of reactivation of verbal\semantic traces during memory retrieval, reducing the likelihood of those visual traces being activated sufficiently enough to produce an endorsement response.

Figure 15: A Source Monitoring Derived Framing of the Misinformation Effect

This framing of the misinformation effect paradigm has several interesting implications. Firstly, in the context of this study, this framework emphasizes why individual differences in the tendency to attribute verbally presented information to a
visual source (i.e., picture as word errors) would be associated with the tendency to attribute verbally presented misinformation to a visually presented event. Specifically, both responses reflect a similar type of source-monitoring error wherein verbal\semantic memory traces are misattributed as being evidence of visual study. Secondly, this framework potentially accounts for why visualization based measures fail to predict misinformation susceptibility as misinformation memory traces draw primarily on semantic information without the need to recruit visualization based processes. Drawing on models proposing a shift towards semantic\gist-related functioning in older adults (Balota et al., 1999; Tun et al., 1998), this framework also anticipates the generally higher levels of misinformation susceptibility in older populations (see Wylie et al., 2014 for a review), which thus far has been attributed to general deficits in source monitoring ability. One prediction of this framework is that the misinformation susceptibility differences between older and younger adults will be reduced using a modified variant of the reversed-misinformation design (Lindsay & Johnson, 1989b) in which participants are presented with a narrative followed by a visual event and tested on their memory of the narrative, or in the context of designs involving the administration of visual event and visual misinformation details.

This model also predicts that test instructions promoting the use of visual feature based criteria at test (e.g. “make sure you can form a firm visual image of the event detail”) will lead to reduced levels of misinformation susceptibility, which is contrary to the misinformation-visualization framework which would instead anticipate visualization effort at recall to be a strong driver of real-world false memory (Lindsay & Read, 1995; Paddock & Terranova, 2001). This contrary prediction is not without precedence,
however, as prior work in the context of false childhood memories has shown that active visualization during memory retrieval can promote true event memories without enhancing false memory report rates (Qin et al., 2008). In addition to this prediction, the model in Figure 15 also suggests that test instructions aimed at biasing participants towards relying on semantic traces (e.g., “make sure you can clearly recall the narrative surrounding that event detail”) are likely to elevate levels of perceptual misinformation endorsement. Another hypothesis, which also builds on this framing of the misinformation effect as a source monitoring paradigm, draws on the link it predicts between misinformation susceptibility and individual differences in the susceptibility towards temporal source-monitoring errors (i.e., the tendency to misattribute recently studied material to an earlier temporal stage). This prediction draws on work showing reduced levels of dropoff in misinformation based memories relative to true memories over time (Frost & Weaver, 1997; Thomas et al., 2017) which, in addition to reflecting the relative strength of semantic memory features, may also be partly driven by higher levels of temporal trace strength. As the misinformation narrative is presented after the event narrative, resulting in the elevated strength of the temporal features associated with misinformation memory traces. Indeed, researchers have long acknowledged that the recency of the misinformation narrative relative to event study is likely to be one of the contributing factors in the misinformation effect (Morton et al., 1985). However, the possibility of individual differences in the tendency to misattribute more recently studied material to earlier event encoding stages, something which could be assessed using an interpolated list design, has yet to be directly assessed.
It would also be interesting to test the prediction of this model that visualization related features of misled information play a minimal role in driving perceptual misinformation endorsements. One way to do so would be to administer a variant of the misinformation effect paradigm in which the sentences of the verbal narrative are alternated between encoding-test trials of a task that either required participants to maintain a visualized precept (e.g., a visual working memory task) or non-visual one (e.g., an auditory tone sequence). In addition to this, it would also be interesting to explore these effects using implementations of the misinformation effect design in which the event contains more semantic/verbal/auditory information such as spoken voices. It would be particularly interesting to explore these links in the context of ear-witnessing in which the original event is present completely in auditory form (e.g., spoken conversations).

Another important point to consider is the potential mode specific differences in quality and relative strength in the semantic traces formed during visual and verbal processing. In Figure 15 the magnitude of the strength of semantic features formed during visual event processing is presented as being slightly weaker than those formed during verbal event processing. This is however only one of several possibilities as a reliance on verbal\semantic features relative to visual ones could lead to elevated misinformation susceptibility, regardless of the strength of the semantic traces formed during the visual event processing stage, through (1) raising the difficulty of source differentiation (in the case of strong semantic traces from the visual event stage) or (2) increasing the reliance on narrative semantic features (in the case of weak semantic traces from the visual event study). Shedding light on the relative strength of formed semantic traces in both visual as
well as verbal processing and the potential for individual differences in these domains thus represents an important direction for continued study.

On a final note, it would be important to assess the longitudinal stability of the individual difference effects observed in this investigation. Currently, little research has been conducted on the stability of individual differences in source monitoring ability across time. While some research has shown performance on false memory tasks such as the Deese-Roediger-McDermott (DRM) paradigm to have decent temporal stability (Hastie et al., 2009) little is known about the temporal stability of other source monitoring tasks such as the misinformation effect. While some work on habitual misinformation acceptance has been conducted by Cann and Katz (2005) and Tomes and Katz (1997), this research focused on identifying factors that predicted habitual susceptibility as opposed to assessing the stability of individual differences in misinformation susceptibility (i.e., test-retest stability). Another investigation by Ost et al. (2013) did show reasonable test-retest reliability (r = .57). However, participants in Ost et al. (2013) were questioned on the same event with the same test at varying time points, making it hard to disentangle the contribution of stable individual differences in misinformation susceptibility on a single set of stimuli versus stability across a range of different events. Thus it would be important to assess if the effects observed in the studies presented in this dissertation reflect individual traits that are relatively stable over time as opposed to more transient state related effects.
6.1 Conclusions

In conclusion, this dissertation presents a series of studies which generally support the idea that semantic/verbal processes may play a stronger role in driving misinformation susceptibility relative to visualization. These results suggest that individual differences in preferences towards relying on semantic/verbal sources of information may play a key role in driving misinformation susceptibility in designs in which the misinformation is presented verbally in narrative form. These findings also broadly highlight the potential unexplored dynamics of modality-specific processing in the misinformation effect, setting the stage for many interesting future directions of continued exploration.
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Appendix B

Misinformation Narrative 1

1. On a cloudy afternoon, a young man wearing a blue t-shirt and purple hat walked down a residential street.
2. He noticed a light purple car parked approximately 15 feet from a large tree across the street.
3. He crossed the street and walked towards the car.
4. He looked into the car, which had a Johns Hopkins University sticker on the rear window.
5. He tried to open the driver-side door.
6. He looked around suspiciously to see if anyone noticed him by the car.
7. He used a credit card (hanger) to open the car door.
8. The door opened.
9. The young man pulled the driver's seat back so he could get in.
10. He then opened the change compartment.
11. He saw several bills and a few pennies in the compartment.
12. He examined the bills, and saw that they were all $1.00 ($20.00) bills.
13. He put the money into his pocket.
14. He then looked into the back seat of the car.
15. He saw a purse and picked it up.
16. He found a purse and rummaged through it with his right hand.
17. Finding nothing in it, he threw down the purse in frustration.
18. Angry, the young man wondered what to do next.
19. The young man decided to look in the trunk and pulled the trunk lever to open it.
20. He got out of the car.
21. He headed towards the trunk closing the front door (leaving the front door open) behind him.
22. He approached the trunk to see if the lever had worked.
23. He saw that the trunk had opened.
24. He opened the trunk all the way.
25. The young man was pleased with what he saw in the trunk.
26. He suddenly heard a sound nearby.
27. He suspiciously looked across the street and saw nobody (a man walking his dog) there.
28. He turned his attention back to the trunk.
29. He pulled out a bag of cocaine (marijuana).
30. He also found a few necklaces (rings and a watch).
31. He put all of the items in his pocket, hoping nobody was in the Toyota vehicle that was parked behind him.
32. He then closed the trunk door.
33. He accidentally slammed the trunk door on his left (right) hand.
34. Furious and in pain, he hit (kicked) the car.
35. With a pained look on his face and holding his hands together, he walked towards the passenger-side door.
36. He approached the door.
37. He opened the door and got in.
38. He opened the glove compartment.
39. He rummaged through the compartment.
40. He found nothing (a cassette tape) in there.
41. He then pulled down the sunshade and found a key (paper slip).
42. Not interested in it, he closed the sunshade.
43. The young man then got out of the car.
44. He closed the door.
45. He noticed that his left (right) shoe was untied and bent down to tie it.
46. He stood up and wondered if there was anywhere else to look in the car.
47. Suddenly, he heard police sirens in the distance.
48. He looked around to see in which direction it was coming from.
49. He then began to run in the opposite direction.
50. As he ran away as quickly as he could, his hat fell off.
1. A petite girl was walking down Main Street in Baltimore.
2. She was window shopping and continued walking.
3. She stopped to look at a video store after passing a hair salon.
4. She decided to go inside.
5. She bought something inside, and left the video store.
6. On her way up the stairs from the store, she saw a friend.
7. She waved hello, and he smiled.
8. The two friends hugged.
9. They chatted for a little while.
10. The girl indicated that she had bought something from the video store.
11. She showed her friend the new South Park (X-files) DVD.
12. Her friend did not approve (approved) of her selection.
13. They continued to talk.
14. They then hugged (waved) goodbye.
15. They walked in opposite directions.

16. The girl continued down Main Street, passing by another woman, and avoiding a paper plate on the ground.
17. A man was walking across the street towards the petite girl.

18. The man was headed directly towards the girl, who was oblivious to him as she walked by the cafe that served organic coffee (tea).
19. The man bumped into the girl from behind (the front).
20. This bump caused her bag to fall to the ground.
21. Her new DVD, sunglasses, mirror and other things fell out of the bag.

22. The girl rubbed her arm (neck), bruised from him bumping into her.
23. The man apologized for running into her.
24. She was angry because all of her items were wet and on the ground.

25. Both of them stooped to the ground to pick up the items and the girl noticed his shoe laces were nicely tied (untied).
26. He placed her mirror (sunglasses) back in the plastic bag, while she picked up her tape dispenser.
27. The girl stood up and turned around to make sure nothing else had fallen out.
28. While her back was turned, the man reached with his left (right) hand into her pocketbook.
29. He took her wallet and put it away in his jacket (pants) pocket.
30. He returned to helping her with her bag that had a yellow smiley face on it.
31. Both of them stood up, and wiped snow off of themselves, as a Bud Light truck honked at the intersection.
32. She shook his hand to thank him for helping her out.

33. The man headed back towards the street, first watching a man who was getting something out of his trunk.
34. The man crossed the street.
35. As the girl continued down the street, the woman talking on her cell phone was finishing her conversation.
36. The girl opened her pocketbook to get out her ringing cell phone to answer it (scarf. because the wind was blowing and she was cold)
37. Suddenly she realized that her wallet was missing.
38. She searched frantically in her bag for her wallet.
39. The woman who had been on the cell phone called out to the petite girl.
40. Concerned, the woman explained to the girl what she had seen the man do.
41. She pointed towards the direction the man headed.
42. The girl looked across the street to see if he was there.
43. Unfortunately, the man had already disappeared.
44. She turned back to the girl with a disappointed look.
45. She shrugged her shoulders, realizing that she would not be able to catch up with him now.
46. The girl thanked the woman for trying to help her.
47. The two headed in opposite directions.
48. The petite girl turned a corner and disappeared.
49. The other side of the street still looked empty.

50. However, the man had been hiding behind a doorway (tree) the whole time, watching them.
1. Setting up for a friendly game of poker, Dirk and Jenny divided 10 red, blue, and white colored chips for themselves.
2. Jenny began to deal the cards.
3. Jenny dealt five cards to Dirk and herself.
4. After throwing in one white chip each, they both looked at the cards they were dealt.
5. Dirk decided to bet two white chips.
6. Jenny saw Dirk's two white chips and decided not to raise him.
7. Dirk placed two cards face down on the table to exchange.
8. Jenny placed one card face down on the table to exchange.
9. After examining his new hand, Dirk bet two blue chips.
10. Jenny lost the first round and was disappointed.
11. Jenny, thirsty, got up from the table.
12. She walked into the kitchen to get a drink for the two of them.
13. While Jenny was getting the bottle of tequila, Dirk stole three blue (white) chips from the extra stack of chips on the table.
14. He blended the stolen chips into his pile of chips as Jenny got two glasses.
15. Jenny walked back towards the table with a full bottle of tequila and two glasses.
16. Jenny handed a glass to Dirk.
17. Dirk started to distribute the cards for a new round.
18. They looked at their cards.
19. Dirk saw that he had five diamonds (spades), a flush.
20. Feeling lucky with his set of cards, Dirk bet five blue (Red) chips.
21. Dirk was confident that he would win this round.
22. Jenny, knowing that he had beaten her, was very upset.
23. Many hours later, Dirk was clearly winning in the midst of an empty (full) bottle of tequila and glasses strewn about the table.
24. Dirk again won another round and was very pleased.
25. Jenny, frustrated and having had enough, pointed at Dirk's growing pile of chips and accused him of cheating.
26. Extremely angry, she got up from the table.
27. With her arms raised, she approached Dirk.
28. Dirk stood up with his arms raised over his face, prepared to fight in defense (ready to fight).
29. Jenny grabbed Dirk by his shirt.
30. Jenny swung her right arm back.
31. She punched Dirk in the face.
32. Dirk fell over onto the ground, holding his face and knocking the chair over.
33. Jenny kicked Dirk in the stomach while he was lying on the ground.
34. Dirk, injured, was curled up on the ground.
35. Jenny stopped kicking but was still very angry and dissatisfied (and was surprised and scared at what she had done).
36. She looked around the room.
37. She picked up her cell (the apartment) phone.
38. She dialed 911.
39. Muffling her voice, she called for help.
40. Jenny quickly headed towards the table.
41. She grabbed the two glasses.
42. She walked over to the sink.
43. She started washing to get rid of fingerprints, using the sink by a poster that said "Homer and 7 Little Duffs".
44. She washed her glass (the two glasses) and put it (them) back.
45. Jenny picked up her book bag first, then her coat. (coat … book bag)
46. She checked on Dirk one last time and he was unconscious (barely conscious).
47. She headed towards the door.
48. She opened the door quietly.
49. She carefully walked out the door, looking around, hoping no one would see her.
50. Leaving her hood down (up), she quickly walked down a set of stairs hidden by a brick building.
1. The computer in the lab had just crashed and the research assistant was angry.
2. Frustrated, she smacked the top of the computer but it did not help.
3. She put her hands on her head, not knowing what to do.
4. *The RA decided to call a repairman and got the paper with the number on it from the bulletin board.*
5. She went over to a desk and picked up the phone.
6. She called the repairman to ask him to come fix the computer.
7. *They agreed on 10am (3pm) and she wrote down the time so she would remember.*
8. She sat down and glared at the computer again.
9. *She decided to read the assigned article in Nature (Science) for class while she waited.*
10. *She made notes on the article.*
11. The RA thought it might be a good idea to put away her wallet in the desk drawer.
12. She heard someone and looked up.
13. She was happy to see the repairman, who was wearing an orange jacket, at the door waving hello with his left (right) hand.
14. They said hello and shook hands.
15. *The repairman asked the RA which computer was broken, and still holding the magazine in her right hand, she pointed to the computer by the white board.*
16. The repairman opened his tool bag to start working.
17. The RA asked if she could leave him to fix the computer, and the repairman gave her an “OK” sign.
18. The RA smiled and waved goodbye.
19. *The repairman sat down at the computer and typed something on the keyboard (tried to click on something with the mouse).*
20. That didn’t work, so using his right arm, he turned off the monitor.
21. *He took out red pliers (a red wrench) from his tool bag.*
22. He looked behind the CPU.
23. He examined the cords behind the computer.
24. Finding nothing wrong, he went back to the tool bag.
25. *He took out a blue (yellow) screwdriver next to open up the computer.*
26. Tired of working on the computer, he stood up.
27. He wiped his forehead with a white cloth (his hand).
28. He was frustrated with the computer.
29. He sat down in the chair.
30. He suspiciously looked back towards the door to see if anybody was nearby.
31. There was no one around, so he opened the top drawer of the desk.
32. *He took a stack of CDs out of the drawer (put a stack of CDs into his toolbag).*
33. *He put a computer mouse in his tool bag (took a computer mouse out of the drawer).*
34. The repairman cautiously looked back towards the door.
35. He heard the RA approaching and closed the top drawer.
36. *He entered the lab with a coffee mug in her hand (nothing).*
37. She pointed to the computer and asked if it was fixed.
38. He shook his head no and told her he couldn't find the problem.
39. She was very upset, so he told her he would try again.
40. The RA sat down at another computer in an adjoining room to the lab.
41. The repairman looked at the RA to make sure she was not looking at him.
42. He opened the top drawer again and saw the wallet.
43. He opened the wallet quietly
44. *He decided to take a credit card (several bills).*
45. *He put the items in his tool bag (pocket).*
46. He stood up with his tool bag.
47. He told the RA that he couldn’t fix the computer and said goodbye.
48. *He left the lab.*
49. There was no sight of him in the hallway to the right side of the lab.
50. *Nor was there anything in the hallway to the left side of the lab except for an empty blue carton.*
## Appendix C

### Study 1 Full Misinformation Task Response Intercorrelations (Condition-Response-Source Attribution)

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** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Abbreviations: MIS = Misinformation, CTL= Control, S&R = Seen and Read, REJ = Rejection, END = Endorsement
### Appendix D

#### Study 2 Full Misinformation Task Response Intercorrelations (Condition-Response-Source Attribution)

|                  | CTL-REJ Seen | MIS-END Seen | CTL-REJ Read | MIS-END Read | CTL-REJ Both | MIS-END Both | CTL-REJ Guess | MIS-END Guess | CTL-END Seen | MIS-END Read | CTL-END Both | MIS-END Guess | CTL-END Seen | MIS-END Read | CTL-END Both | MIS-END Guess | CTL-END Seen | MIS-END Read | CTL-END Both | MIS-END Guess |
|------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| MIS-END-Seen     | -.131        |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |
| CTL-REJ-Read    | -.127        | .338**       | -.300**      | -.300**      | -.041        | -.073        | .020         |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |
| MIS-END-Read     | .424**       | -.300**      | -.300**      |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |
| CTL-REJ-Both    | -.049        | -.165*       | -.045        | -.039        | .020         | .073         | .020         |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |
| MIS-END-Both     | .011         | -.030        | -.270**      | .084         | -.221**      | -.120        |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |
| CTL-REJ-Guess   | -.032        | -.046        | -.073        | -.129        | -.153        | -.171        | .486*        |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |
| MIS-END-Guess   | -.433**      | -.103        | -.072        | -.187        | -.221**      | -.025        | -.416**      | -.258**      |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |
| CTL-END-Seen     | -.295**      | .005         | .179*        | -.582**      | .053         | -.252**      | -.316**      | -.339**      | .361**       |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |
| CTL-END-Read     | .387**       | -.067        | -.068        | .231**       | .076         | -.063        | -.018        | -.079        | -.380**      | -.154        |              |              |              |              |              |              |              |              |              |              |              |              |              |              |
| CTL-END-Both     | .198**       | -.127        | -.128        | .014         | -.069        | .043         | -.097        | -.041        | .043         | -.177        | .199**       |              |              |              |              |              |              |              |              |              |              |              |              |              |
| MIS-END-Read     | .198**       | -.127        | -.128        | .014         | -.069        | .043         | -.097        | -.041        | .043         | -.177        | .199**       |              |              |              |              |              |              |              |              |              |              |              |              |              |
| MIST-END-Both    | .081         | -.215**      | -.069        | -.033        | .248**       | .313**       | -.256**      | -.225**      | -.335**      | .088         | -.050        | .046         |              |              |              |              |              |              |              |              |              |              |              |              |
| MIS-END-Guess   | .007         | -.025        | .115         | -.166        | .207**       | .013         | -.180        | -.151        | -.071        | -.071        | .044         | -.022        | .158*        |              |              |              |              |              |              |              |              |              |              |              |
| CTL-END-Guess   | .023         | -.104        | -.258**      | -.180        | -.222**      | -.102        | .424**       | .449*        | -.416**      | .374**       | -.045        | -.112        | -.271**      | -.111        |              |              |              |              |              |              |              |              |              |              |
| MIS-END-Guess   | -.087        | .054         | .005         | -.138        | -.170        | -.194**      | .474**       | .541**       | -.269**      | -.423**      | -.054        | -.071        | -.241**      | -.045        | .452**       |              |              |              |              |              |              |              |              |              |

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Abbreviations: MIS = Misinformation, CTL= Control, S&R = Seen and Read, REJ = Rejection, END = Endorsement

Footnote: Control item rejections = Foil response selection, Misinformation Rejection = Selection of original event item
Appendix E

Study 3 Misinformation Task Response Intercorrelations (Condition-Response-Source Attribution)

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** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
Abbreviations: MIS = Misinformation, CTL= Control, S&R = Seen and Read
Appendix F

Study 4 Full Misinformation Task Response Intercorrelations (Condition-Response-Source Attribution)

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