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Who is susceptible in three false memory tasks?

Rebecca M. Nichols[a] and Elizabeth F. Loftus[b]

[a]School of Social Sciences, Nanyang Technological University, Singapore, Singapore; [b]Psychology and Social Behavior, University of California, Irvine, CA, USA

ABSTRACT

Decades of research show that people are susceptible to developing false memories. But if they do so in one task, are they likely to do so in a different one? The answer: "No". In the current research, a large number of participants took part in three well-established false memory paradigms (a misinformation task, the Deese-Roediger-McDermott [DRM] list learning paradigm, and an imagination inflation exercise) as well as completed several individual difference measures. Results indicate that many correlations between false memory variables in all three inter-paradigm comparisons are null, though some small, positive, significant correlations emerged. Moreover, very few individual difference variables significantly correlated with false memories, and any significant correlations were rather small. It seems likely, therefore, that there is no false memory "trait". In other words, no one type of person seems especially prone, or especially resilient, to the ubiquity of memory distortion.

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As much as we would like to believe so, human memory is not the foolproof gatekeeper of our past. Though our memories generally serve us well in our day-to-day lives and contribute meaning to ourselves and the physical and social environments in which we are so deeply embedded, we do not encode and retrieve in a failsafe record-and-playback manner. Rather, our memory processes can be vulnerable to contamination and distortion. Our memories are malleable, susceptible to influence from suggestion, and can even contain whole events that never actually occurred.

The past four decades have seen an explosion of research investigating the psychological underpinnings of faulty memory (for a review of some of this work and its motivations, see Brainerd & Reyna, 2005 or Loftus, 2017). This collective body of work has shown that memories can be manipulated experimentally. This holds for memories of simple events created in the lab and memories for perceptually rich and personally meaningful events from one's past. What's less known, however, is whether individuals who are particularly prone to developing false memories in one context are also prone to developing phenomenologically different false memories in other contexts. We examined this issue using three commonly used paradigms for demonstrating memory malleability. We describe their methods, their theoretical bases, and individual differences that predict susceptibility below.

The misinformation effect

Background and theory

One commonly used paradigm involves exposure to misinformation about a past memory (Loftus, Miller, & Burns, 1978). In a typical misinformation study, participants witness some type of event and later are given some misinformation (i.e., inconsistent post-event information) about that event. When tested on their memory for event details, participants often incorporate pieces of misinformation into their memory of the original event and report those details as such. For example, participants in one study viewed a slideshow in which a burglar picked up a hammer, then sometime later read misleading information that the burglar handled a screwdriver instead. At test, they were asked whether they saw a hammer or a screwdriver in the original slideshow. Across experiments, participants selected the misinformation item – the screwdriver – 66% of the time, representing a typical pattern of memory impairment in misinformation studies (McCloskey & Zaragoza, 1985).

One of the predominant theoretical explanations for the misinformation effect is that of errors in source monitoring (Johnson, Hashtroudi, & Lindsay, 1993). The source monitoring account states that when participants encode the misinformation, they may not adequately encode the source of the post-event information and thus erroneously attribute it to the original event (for reviews, see Belli &

CONTACT Rebecca M. Nichols r.nichols@ntu.edu.sg School of Social Sciences HSS-04-26, Nanyang Technological University, 48 Nanyang Avenue, Singapore 639818, Singapore

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Loftus, 1994; Mitchell & Johnson, 2000; Zaragoza, Lane, Ackil, & Chambers, 1997). This can easily happen because the original information and misinformation share some commonalities (e.g., the referent event and the context in which those events occur) that inherently make source distinction difficult. Johnson et al. (1993) identified a number of conditions in which source misattributions are particularly likely, which include imagining perceptual detail at the time of encoding misinformation, encoding misinformation that is particularly congruent with the overall meaning of the event, and experiencing stress or fatigue during encoding of the misinformation.

Another approach to explaining misinformation false memories is fuzzy trace theory (FTT; Brainerd & Reyna, 2005). FTT posits two types of mental representations for memory: verbatim traces, which are detailed, often vivid, direct representations of the past, and gist traces, which capture overall meaning of the memory but not its specific qualities. According to FTT, endorsement of misinformation is supported by both verbatim and gist trace strength. An individual may misremember the item as a screwdriver because they recall this verbatim information from the misinformation phase, or they may misremember the item as a screwdriver because it is consistent with the overall gist memory that the item was a tool.

Individual differences

Compared to the large corpus of research on the misinformation effect, relatively few studies explore individual differences in susceptibility. Age is one of them; older adults have shown to be more susceptible to memory errors, and this is likely because of decreased frontal lobe functioning and thus poorer source memory discriminability (Roediger & Geraci, 2007). Other research has shown that people who report stronger ability to imagine visual images are more likely to endorse misinformation (Cann & Katz, 2005; Eisen, Gomes, Lorber, Perez, & Uchishiba, 2013; Tomes & Katz, 1997), though imagery ability has also been linked to a close confidence-accuracy relationship in the misinformation paradigm (Tomes & Katz, 2000). Furthermore, a positive association has been found between subscales of the Openness and Agreeableness dimensions of the NEO Personality Inventory and misinformation false memory (Liebman et al., 2002), which is consistent with the idea that social factors play a role in the acceptance of misinformation (McCloskey & Zaragoza, 1985). Furthermore, the degree to which participants self-report dissociative experiences has also been shown as a predictor of incorporation of misinformation into memory (Eisen & Carlson, 1998; Eisen, Morgan, & Mickes, 2002; Hekkanen & McEvoy, 2002), which is not surprising given that those who dissociate (particularly those with pathological dissociation) are likely to suffer from a number of cognitive problems that include limits in source monitoring (Putnam, 1995).

In addition, cognitive factors seem to play a role in understanding one's susceptibility to the misinformation effect. For example, working memory has been shown to be negatively correlated with misinformation-related false memory (Calvillo, 2014; Jaschinski & Wentura, 2002). Relatively low intelligence coupled with poor perceptual capacity is also associated with susceptibility to misinformation (Zhu et al., 2010a). More specifically, individuals with a low degree of cognitive ability combined with traits such as low fear of negative evaluation, low need to avoid harm, high cooperativeness, high dependence on reward, and high self-directedness seemed to be especially susceptible to the influence of misinformation (Zhu et al., 2010b). It may be the case that a specific threshold of cognitive ability is required both to accurately recall witnessed events and to discern the sources of potentially competing information about those events.

The Deese-Roediger-McDermott paradigm

Background and theory

Nearly twenty years after the misinformation effect was demonstrated, Roediger and McDermott rediscovered the work of Deese (1959) and developed what became another widely used experimental manipulation designed to induce false memories, the Deese-Roediger-McDermott (or DRM) paradigm (Roediger & McDermott, 1995; Stadler, Roediger, & McDermott, 1999). In the DRM, participants view or hear lists of semantically-related words such as *note*, *sound*, *piano*, *sing*, *radio*, *band*, etc., which converge upon a critical, non-presented semantic associate (in this case, *music*). Participants are tested on their memory for studied items, new but unrelated control (distractor) items, and of most interest, critical items. The rate of false memories for critical items during encoding often approximates or exceeds that of veridical memory for studied items, and these patterns have been robustly replicated in the DRM literature (for reviews of the DRM, see Gallo, 2006; 2010).

One theory that accounts for false memories in the DRM is the activation-monitoring hypothesis (Roediger & McDermott, 2000; Roediger, Watson, McDermott, & Gallo, 2001). This theory posits that the critical item is mentally generated both at encoding and potentially during retrieval as a result of spreading activation, a process by which nodes that represent concepts in a semantic network are activated due to the proximity and magnitude of activation of other nodes (Underwood, 1965). Faulty monitoring during study then produces source confusions at test, and participants mistakenly remember the critical item as having been presented, instead of merely cognitively activated, at study. FTT has also been proposed to explain DRM memories; from an FTT perspective, false recognition of *music* at test may occur because it is consistent with overall gist memory that the list contained items converging upon music (Cabeza & Lennartson, 2005).

Individual differences

Relative to the misinformation effect, individual predictors of susceptibility to false memories of critical lures in the

DRM have been extensively studied. Just as with the misinformation effect, age is negatively correlated with DRM false memories in adults (Balota et al., 1999; Butler, McDaniel, Dornburg, Price, & Roediger, 2004; Gallo, Bell, Beier, & Schacter, 2006; Kensinger & Schacter, 1999). With respect to the NEO Personality Inventory, extraversion has been shown to correlate with false memory susceptibility. Specifically, extraverts have been shown to falsely remember more critical lures than both introverts and ambiverts (Sanford & Fisk, 2009). This finding is consistent with evidence that suggests extraversion is correlated with heightened arousal, which in turn increases spreading activation and thus leads to greater effects of semantic priming (see Matthews & Harley, 1993).

Furthermore, many studies have found a positive correlation between dissociative experience and false memories in the DRM (Clancy, McNally, Schacter, Lenzenweger, & Pitman, 2002; Clancy, Schacter, McNally, & Pitman, 2000; Dehon, Bastin, & Larøi, 2008; Wilkinson & Hyman, 1998; Winograd, Peluso, & Glover, 1998; Zoellner, Foa, Brigidi, & Przeworski, 2000), though some studies have failed to observe such a relationship (e.g., Bremner, Shobe, & Kihlstrom, 2000; Geraerts, Smeets, Jelicic, van Heerden, & Merckelbach, 2005; Platt, Lacey, lobst, & Finkelman, 1998; Wright, Startup, & Mathews, 2005). Positive correlations also exist between DRM false memories and measures of delusional ideation (Dehon et al., 2008; Laws & Bhatt, 2005) and fantasy proneness (Geraerts et al., 2005) as well as imagery ability (Winograd et al., 1998). The discovery of these relationships suggest that an overall predisposition toward moving thoughts from consciousness, or otherwise holding imaginative beliefs more generally, may be related to overall worse memory (and more specifically in this case, a greater likelihood of using similarity to judge critical lures as having been actually encoded).

Researchers have also studied a number of cognitive variables as predictors of false memories in the DRM. A growing body of research has demonstrated a negative correlation with working memory (Parker, Garry, Engle, Harper, & Clifasefi, 2008; Peters, Jelicic, Haas, & Merckelbach, 2006; Peters, Jelicic, Verbeek, & Merckelbach, 2007). This relationship appears to be stronger under conditions that call for a high degree of source monitoring, such as when participants are forewarned about the types of memories errors the DRM tends to produce (Watson, Bunting, Poole, & Conway, 2005). On the other hand, individuals who report a higher number of everyday mental errors (or who report less cognitive efficiency) have demonstrated reduced susceptibility to endorsement of critical lures (Raymaekers, Peters, Smeets, Abidi, & Merckelbach, 2011), suggesting that those with a more optimistic view of their own cognitive efficiency may have a global tendency to make liberal memory judgments, which in turn leads them to endorse more critical lures. Though the DRM does produce memory errors, results such as these illuminate the rationale to consider response biases in addition to (not instead of) memory errors.

Another cognitive variable implicated in individual difference research on the DRM is cognitive style, or one's preferred general approach to information processing (see Sternberg, 1997, for a review). One way to measure cognitive style is with the Need for Cognition (NFC) scale, which measures the degree to which one prefers to engage in effortful thinking (Cacioppo & Petty, 1982). Individuals higher in NFC have been shown to be more susceptible to DRM errors in both tests of recognition (Graham, 2007) and recall (Leding, 2011; Wootan & Leding, 2015). It is perhaps the case that those with greater NFC engage in more elaborative cognitive processing or have more integrated semantic networks that allow for easier false retrieval of nonpresented critical lures at test. There is also evidence to suggest that one's Faith in Intuition (FI), a construct that is orthogonal to NFC in the Rational-Experiential Inventory (see Epstein, Pacini, DenesRaj, & Heier, 1996) and which gauges one's reliance on intuitive thought, is positively correlated with false memories in the DRM (Nichols & Loftus, 2009). When *music* is presented at test, participants may experience an immediate and intuitive feeling that it had been presented during encoding, and this may be an especially operant mechanism for false memory development in those who tend to rely on their "gut feelings" more often than others more generally. Lastly, it has also been shown that people with a field-dependent processing style, who rely on background and holistic information in order to process globally, are more susceptible to false memories than their field-independent counterparts, who can more easily identify individual, constituent elements apart from the whole (Corson, Verrier, & Bucic, 2009). This is an intuitive finding consistent with implications from spreading activation theory; DRM items themselves contribute to part of a whole (the relevant list, which semantically converges upon the lure), and those who are more likely to process those items holistically are more likely to endorse the lure.

Finally, it is important to note briefly that the proneness to DRM errors itself is considered itself a stable individual difference; one study demonstrated a correlation of $r = .76$ between false alarms to lures at Time 1 and those of Time 2, two weeks later (Blair, Lenton, & Hastie, 2002).

Self-relevant false memories: imagination inflation

Background and theory

Several studies have shown that people can develop false memories for whole autobiographical events. During the highly profiled repressed memory cases of the 1990s, when claimants purported to have had experienced but subsequently repressed unspeakable crimes such as ritual satanic abuse (see Bottoms & Davis, 1997), it became clear that more work was needed to investigate whether or not memories for entire events could be implanted. And so was born a new line of false memory research: that of personally relevant false memories. Unlike their misinformation and DRM counterparts, these memories may

be comprised of whole, richly detailed events of one's own personal past (see Loftus & Bernstein, 2005 for a review). One of the first studies to implant false autobiographical memories did so with the lost-in-the-mall technique (Loftus & Pickrell, 1995). In this study, participants were given short narratives of events that occurred in the past, and for all participants in the study, one of the stories was about having gotten lost and subsequently found by a family member in a shopping mall during childhood. Unbeknownst to the participants, family members had previously verified this event never to have happened for any of the participants. In the original study, a sizeable minority (i.e., 25%) of participants remembered the fictitious lost-in-the-mall event after being subjected to a suggestive interview.

Since then, self-relevant false memories have been implanted using a variety of experimental techniques, including dream interpretation (Loftus & Mazzoni, 1998; Mazzoni, Lombardo, Malvagia, & Loftus, 1999), guided visualisation (Paddock, Terranova, Kwok, & Halpern, 2000), hypnosis (Spanos, 1996; Spanos, Burgess, Burgess, Samuels, & Blois, 1999), false feedback (Bernstein, Laney, Morris, & Loftus, 2005a, 2005b; Laney, Morris, Bernstein, Wakefield, & Loftus, 2008; Laney & Loftus, 2008), doctored photographs (Strange, Sutherland, & Garry, 2006; Wade, Garry, Don Read, & Lindsay, 2002), and doctored video (Nash & Wade, 2009; Nash, Wade, & Lindsay, 2009). Another technique used to implant false memories is guided imagination (Garry, Manning, Loftus, & Sherman, 1996). In a typical guided imagination study, participants are given a number of childhood events and are asked to rate their confidence that they experienced each event as a child. Participants are later asked to imagine one of the events and, sometime later, fill out another identical life events inventory. An increase in confidence from the first inventory to the second for the critical event (relative to the other, control events) lends evidence toward the formation of a false memory for that event, and this effect has been termed *imagination inflation* (Garry et al., 1996). This phenomenon is often further supported by the participants' report of a belief or an actual memory that the event occurred (see Bernstein et al., 2005a, 2005b for studies that utilise memory-or-belief questionnaires).

Source misattributions may help explain imagination inflation. Whereas the misinformation effect is due to *external* source attributions (to the original event instead of to the post-event narrative or questioning), imagination inflation is believed to be due to *internal* misattributions (to one's autobiography instead of to one's imagination; Johnson et al., 1993). Another proposed explanation for imagination inflation comes from the familiarity misattribution hypothesis (Jacoby, Kelley, & Dywan, 1989), which explains that when an event is imagined, the imagination exercise renders the event more familiar and cognitively available, which in turn results in false recollection. Researchers have demonstrated, however, that imagination inflation is more likely to occur when participants incorporate detailed sensory elaborations during imagination and not when imagined events lack sensory cues or are otherwise not imagined with such perceptual precision (Thomas, Bulevich, & Loftus, 2003). Thus, it is possible that feelings of familiarity can facilitate the imagination inflation effect, but it seems likely that source misattributions account for inflation over and above explanations related to increased general familiarity or ease of processing.

One criticism of imagination inflation studies is that the imagination exercise actually allows the participant to access a previously inaccessible yet *true* event from one's childhood, and the increase in confidence is an artifact of this process (Pezdek & Salim, 2011). One experimental variant of the imagination inflation paradigm addresses this concern. In this modified paradigm, adapted from Goff and Roediger (1998), participants come into the lab and hear a list of actions, some of which are everyday tasks (e.g., *flip a coin*) and some of which are bizarre (e.g., *kiss the magnifying glass*). At a later time, they return and imagine some of the performed events as well as some novel events. Finally, participants return later for a third and final time in which their memory is tested for the actions performed in Session 1. One study that utilised these methods found that repeated imagination led people to report that both everyday and bizarre actions were performed during Session 1 when in fact they were merely presented, imagined, or even neither of the two (Thomas & Loftus, 2002). Because the referent events were controlled by the experimenters, the research directly addressed the issue concerning the potential access of true memories and confirmed imagination indeed inflates false memory.

Individual differences

Few studies have examined individual differences in susceptibility to false memories that develop through guided imagination. However, it is useful to turn to the small literature that has identified individual difference predictors of false autobiographical memories across other experimental manipulation types. Most of these individual differences are concerned with traits that are captured by disengagement from reality. For example, one study demonstrated that participants were more likely to falsely remember a childhood event (ostensibly described by their parents) if they were more prone to dissociation as well as if they scored low on extraversion but were interviewed by an experimenter who scored high on extraversion (Porter, Birt, Yuille, & Lehman, 2000). Another study utilising a similar technique also found a positive association with proneness to dissociation as well as fantasy proneness (Hyman & Billings, 1998). In a study that employed guided visualisation, however, dissociation was not related and participants' self-reported extraversion, not introversion, was positively correlated with false memories (Paddock et al., 2000). In yet another study in which participants kept a diary of events and encountered an unexpected memory test six months later, memory intrusions

were found to be related to fantasy proneness but not dissociation, absorption, or suggestibility (Horselenberg, Merckelbach, van Breukelen, & Wessel, 2004). Absorption, a construct closely related to hypnotisability and which has been described as "a disposition for having episodes of 'total' attention that fully engage one's representational (i.e., perceptual, enactive, imaginative, and ideational) resources" (Tellegen & Atkinson, 1974), has been shown to predict false memories related to the OJ Simpson trial in a study of more naturally occurring memory intrusions (Platt et al., 1998).

As far as guided imagination is concerned specifically, only a few studies have identified individual difference predictors of developing a false memory. Working memory has been shown to be negatively correlated with false memory for imagined events in the lab (Peters, Smeets, Giesbrecht, Jelicic, & Merckelbach, 2007) and imagined childhood events (Calvillo, Vasquez, & Pesavento, 2018). Proneness to dissociation has correlated positively with inflation (Heaps & Nash, 1999) though some studies have failed to find such a relationship (Horselenberg et al., 2000; Mazzoni & Memon, 2003). Hypnotic suggestibility has also been shown as a predictor of inflation (Heaps & Nash, 1999), as has the ability to visualise or generate mental imagery (Horselenberg et al., 2000), though this relationship has not held in other studies (Heaps & Nash, 1999; Mazzoni & Memon, 2003). It is clear from the literature review of imagination inflation and of autobiographical false memories more generally that there is mixed evidence for many potential individual difference predictors. This is especially true for those traits that cluster around disengagement from conscious awareness such as dissociation, absorption, hypnotisability, and fantasy proneness.

Relatedness of paradigms

Theoretical foundations

The three paradigms reviewed thus far all reveal conditions under which memory for events can be manipulated and distorted. Their theoretical underpinnings, however, vary. The misinformation effect can be accounted for by source monitoring theory, which contends that people inaccurately remember misleading information as having occurred during the actual event and not from some post-event source. The DRM can be explained by a combination of monitoring and activation theories in which people misremember studying the critical item during encoding because it was cognitively activated instead of actually presented and encoded. Finally, source monitoring confusions apply to a typical imagination exercise as well, though the confusion lies from internal, rather than external, sources. From a FTT perspective, gist traces support false memory in both DRM and misinformation tasks, while verbatim traces support false memory in the misinformation paradigm (Reyna, Corbin, Weldon, & Brainerd, 2016).

The methodological and theoretical considerations of each type of false memory combine to form a good launching point from which to consider whether performance in one paradigm can itself predict performance in another. That is, to the extent that one falsely recognises the critical lure in the DRM, will this predict his or her proneness to falsely recall an event from the past that never actually happened? Can one's propensity to remember a critical event during an imagination inflation exercise predict the overall likelihood of endorsing post-event information in a typical misinformation experiment? Does the extent to which one remembers a misleading detail about an event inform the likelihood of developing false memories in a word-list task?

Empirical evidence

A few studies have explored possible correlations between false memories arising from different paradigms. One study found that the 32% of children in their sample who developed a false memory after an interview about a fictitious event also displayed higher DRM rates compared to children who did not develop such a false memory (Otgaar, Verschuere, Meijer, & van Oorsouw, 2012). Among studies of adults, one reports a small positive correlation of $r = .12$ between endorsement of misinformation in a standard task and false memories in the DRM (Zhu, Chen, Loftus, Lin, & Dong, 2013). However, other studies have failed to find a relationship between misinformation and DRM false memories (Calvillo & Parong, 2016; Monds, Paterson, & Kemp, 2017; Ost et al., 2013), between DRM and false event suggestion (Otgaar & Candel, 2011), or between imagination inflations for childhood events and for simple actions performed in the laboratory (Calvillo et al., 2018). Only two studies to date have examined correlations between false memories in misinformation, DRM, and false event suggestion manipulations, and both failed to find any correlations among them (Bernstein, Scoboria, Desjarlais, & Soucie, 2018; Patihis, Frenda, & Loftus, 2018). Overall, the research describes largely null relationships between false memories of different paradigms, but none so far have explored false memories specifically in the misinformation, DRM, and imagination inflation paradigms all within subjects. This study aims to address this need.

A note on special populations

There is some evidence that people who can recount extremely anomalous or altogether impossible events are more likely to commit memory errors in classic false memory experiments. The bulk of this evidence comes from research conducted with the DRM paradigm. One study found that participants who self-reported at least one space alien abduction both falsely recognised and falsely recalled more critical lures than a sample of non-abductee controls (Clancy et al., 2002). Another study similarly found that people who report having past-lives (which is, under careful consideration, seemingly *even less* plausible than

an alien abduction) also displayed heightened false recognition and recall rates in the DRM than controls who only reported having one, current, on-going life (Meyersburg, Bogdan, Gallo, & McNally, 2009).

There has been some lingering debate regarding the existence of memory repression (see Patihis, Ho, Tingen, Lilienfeld, & Loftus, 2014; Brewin & Andrews, 2014; Patihis, Lilienfeld, Ho, & Loftus, 2014), but it is of relevance to the discussion of special populations to describe research based on samples who report these types of these experiences. One study found that women who reported recovering repressed memories of childhood sexual abuse (CSA) exhibited higher DRM rates than women who never reported having forgotten the abuse (Clancy et al., 2000). The same pattern was found for a group of women who reported repressing their CSA experiences relative to women reporting either no abuse or no lapse in memory for their abuse (Geraerts et al., 2005). Furthermore, a sample of women who reported recovering memories of traumatic childhood sexual abuse during psychotherapy also exhibited higher false memory rates in the DRM that women who experienced childhood abuse but who were able to recall the event after simple relevant cues (Geraerts et al., 2009).

The overarching idea of these studies is that those who are prone to developing a false memory from their past due to an imagination, suggestion, or something else may also be susceptible to memory distortion in a laboratory setting. It is difficult to conceive a precise mechanism that explains these patterns, in part because these studies are correlational, but also because false memories in the DRM and false autobiographical memories are the result of different manipulations and are themselves qualitatively dissimilar. It is perhaps the case, however, that the relatedness of these memories is most evident for people who lay at one extreme of the proneness spectrum for one or more paradigms. It may also be true that they capture extreme ends of trait distributions that are correlates of false memories across different contexts.

Overview of the research

The first of two primary goals was to investigate the relationships between memory performance in three false memory paradigms administered within subjects: misinformation, DRM, and imagination inflation. Though the use of three paradigms is a methodological and logistic challenge, the benefit of this research design is that any pattern of results will facilitate understanding of the commonalities of false memories that are the result of different methodologies, that are themselves qualitatively unique, and that may be explained by different theoretical mechanisms.

Secondly, this study investigates a number of individual differences as predictors of false memories for each of the paradigms. The purpose of including these measures is to (a) replicate patterns in a normal college-aged sample that have been previously reported in the literature, (b) identify new individual difference predictors of false memory for one or more particular paradigms, (c) investigate which of these measures, if any, seem to commonly predict false memories in all paradigms, and (d) use individual difference correlates to refine proposed mechanisms for false memory development.

Method

Participants

Undergraduate students from a large public university in California ($N = 373$; $N_{Female} = 277$, $N_{Male} = 89$, $N_{Unreported} = 7$; $M_{age} = 20.8$, Asian 42.6%, Latino 25.1%, Caucasian/White 15.3%, Middle Eastern 4.6%, African-American/Black 1.6%, Hawaiian or Other Pacific Islander 0.5%, U.S. Indian 0.0%, Multiple ethnicities 9.0%, Other 1.1%) participated in the study for course credit. Of these participants, $n = 297$ completed the misinformation task, $n = 283$ completed the DRM task, $n = 244$ completed imagination inflation, and $n = 367$ completed individual difference measures. Each of these tasks is described in further detail below.

Materials

False memory paradigms

Misinformation. Participants completed a three-stage misinformation task adapted from Takarangi, Parker, and Garry (2006) using Qualtrics software. In the first stage, participants viewed a silent 6 min 28 s video of a double-crossing electrician who steals personal property while on the job in a client's home. At the conclusion of the video, participants responded to trivia statements for 12 min in order to prevent mental rehearsal of the events in the video.

Participants then read a narrative account of the events witnessed in the video. Each sentence in the narrative appeared one at a time, and participants were able to advance to the next sentence at his or her own pace. The narrative contained eight critical items from the video: *bed, picture, van, time, mug, magazine, drink,* and *cap*. In the narrative, four of the critical items were presented as misinformation items, and four were presented as control items. For example, Eric drinks from a can of Coke in the video. In the narrative, the coke item either presented as misinformation ("Eric helped himself to a can of *Pepsi* from the fridge") or with consistent information ("Eric helped himself to a can of *soft drink* from the fridge") that served for comparison. Participants were randomly assigned to one of two narrative conditions: in Condition 1, four items in the narrative were misinformation items, and the other four items were controls. In Condition 2, the reverse was true: misinformation items from Condition 1 were control items and control items from Condition 1 were misinformation items. After participants read the narrative, they completed basic addition and subtraction math

problems for five minutes again intended to prevent rehearsal of items in the narrative.

The third and final stage of the task involved a recognition test. Participants completed a 20-item, two-alternative forced-choice memory test about events in the original film of Eric the Electrician. For each item, participants also indicated whether they remembered their answers from the video, the narrative, both, or neither. Of the 20 items, four concerned events that contained misleading details in the narrative, four probed about events that contained consistent information in the narrative, and the other twelve questions were fillers in which participants addressed items they both viewed in the video and read about in the narrative. For the eight critical questions, the answer alternatives consisted of the correct item (such as *Coke*) or the misinformation item (such as *Pepsi*). Whether the incorrect alternative for each of these was a misinformation item or a foil depended on the condition the participant was in during the narrative stage.

DRM. Participants viewed the DRM list-learning task in a Microsoft PowerPoint slideshow also embedded into Qualtrics software. Before viewing the presentation, participants were informed that they would see a series of words and that they should try to remember them to the best of their ability. Immediately following this instruction, participants viewed 15 DRM word lists adapted from Stadler et al., 1999 (*anger, chair, doctor, fruit, king, mountain, music, needle, rough, sleep, smoke, sweet, thief, trash,* and *window*). Each word was presented for 1 s followed by a 3 s pause between lists. At the conclusion of the DRM presentation, participants completed the imagination inflation test (see the following section), which also provided a retention interval filler. Following that test, participants completed a 120-item DRM recognition test. The recognition test contained 15 critical items (one from each presented list), 45 studied items (taken from serial positions 1, 8, and 10 of each list), and 60 new, unrelated distractor items (also drawn from critical items and items in serial positions 1, 8, and 10, of lists not used in the presentation). For each item in the recognition test, participants judged whether they had seen it ("OLD") or had not seen it ("NEW") previously in the slideshow and provided a confidence judgment for their decision using a scale anchored at 1 (Not Confident) to 5 (Very Confident). For each item judged "OLD", participants also indicated whether they had a specific memory for having seen the word ("REMEMBER") or if they knew it had been presented but did not experience an actual recollection of the word or could remember any details about it ("KNOW"). These indices were used to distinguish memories from beliefs, respectively.

Imagination inflation. The imagination inflation task, adapted from Goff and Roediger (1998), took place over three in-lab sessions. In Session 1, participants heard 54 action short statements (e.g., *push the toy car*) and either performed them for 15 s (18 statements), imagined performing them for 15 s (18 statements), or only heard the action and then completed math problems for 15 s (to prevent mental rehearsal until the next statement was presented; 18 statements). Half of the action statements included an object (e.g., *flatten the clay*) and nine were non-object action statements (e.g., *nod in agreement*).

After a one-week retention interval, participants advanced through 44 action statements, presented one at a time on individual computers, for which they were instructed to take a few moments to close their eyes and imagine performing the action. After each imagination, participants provided a vividness rating for what they had imagined to help ensure compliance with the imagination instruction. After the imagination exercise, participants were reminded of their appointment for Session 3 and dismissed.

Participants returned for the third and final study session exactly one week after Session 2. This session began with the DRM exercise. Immediately following the DRM recognition test, participants completed the final portion of the imagination inflation paradigm: a recognition test for the action statements presented during Session 1. Each test item was followed by a confidence judgment, similar to the ones made in the DRM, from 1 (Not Confident) to 5 (Very Confident). Upon completion of Session 3, participants were thanked for their time, fully debriefed on the purpose of the study, and awarded participation credit.

Individual differences

Demographics. Participants filled out a basic demographics questionnaire that included questions about their gender, age, ethnicity, number of years speaking English, current GPA, and SAT scores.

Trait personality. Personality dimensions of openness, conscientiousness, extraversion, agreeableness, neuroticism were measured using the 44-item Big Five Inventory (John, Donahue, & Kentle, 1991; John, Naumann, & Soto, 2008). Participants rated their agreement with each item on a 5-point Likert scale (1 = Disagree Strongly; 5 = Agree Strongly).

Cognitive ability and style. Overall cognitive ability was gauged with the 150-item Over-claiming Questionnaire (OCQ; Paulhus & Harms, 2004; Paulhus, Harms, Bruce, & Lysy, 2003), which asks participants to rate their familiarity with a number of historical, scientific, and cultural items on a 5-point Likert scale (0 = never heard of it; 4 = very familiar). To measure cognitive style, participants completed both the 18-item Need for Cognition (NFC) subscale and 12-item Faith in Intuition (FI) subscale of the Rational-Experiential Inventory (REI; Epstein et al., 1996). For both scales, participants indicated how characteristic each statement is of them using a Likert scale (1 = extremely uncharacteristic; 7 = extremely characteristic). Participants also completed the Cognitive Reflection Task (CRT; Frederick, 2005),

a three-item measure designed to gauge a subject's willingness and ability to suppress an intuitive but incorrect answer to a problem and arrive at a correct answer. Finally, participants completed the Vividness of Visual Imagery Questionnaire (VVIQ; Cui, Jeter, Yang, Montague, & Eagleman, 2007; Marks, 1973), which measures how vividly one is able to produce mental images. Participants visualised a number of statements and indicated the vividness of each visual image using a Likert scale (1 = no image, you are only thinking of the object; 5 = image is perfectly clear and as vivid as normal vision).

Disengagement from reality. Participants completed the Dissociative Experiences Scale (DES C; Wright & Loftus, 1999), a measure designed to investigate proneness to dissociation, by rating the frequency of such experiences on an 11-point scale. Absorption was measured with the Tellegen Absorption Scale (TAS; Tellegen & Atkinson, 1974), for which participants rated the frequency of absorptive items on a 4-point scale (1 = never; 4 = always). Finally, participants also completed a measure of fantasy proneness, the Creative Experiences Questionnaire (CEQ; Merckelbach, Horselenberg, & Muris, 2001). For this scale, participants indicated whether or not they experienced as a child, or tend to experience as an adult, events that that involve fantasising.

Religiosity. Participants' internal and external religiosity was measured using the 20-item Age Universal Religious Orientation Scale (AUROS; Gorsuch & Venable, 1983).

Anomalous experiences. Self-reported paranormal and/or anomalous experiences were investigated with the Anomalous/Paranormal Experience Subscale of the Anomalous Experiences Inventory (AEI; Gallagher, Kumar, & Pekala, 1994).

Procedure

The order of events for all three sessions appears in Table 1. Study procedures occurred over three separate in-lab sessions in which up to five participants participated at a time. When participants arrived for Session 1, they first read an IRB-approved study information sheet and consented to participate in all subsequent research activities. Participants were also informed that they could withdraw from participation at any time without receiving any penalty. After consenting to participate, participants completed the demographics questionnaire followed by all other individual difference measures presented in a randomised order. At the end of the questionnaires, participants completed an attention check (adapted from Oppenheimer, Meyvis, & Davidenko, 2009). All procedures up to this point were administered on individual computers. They then engaged in the first part of the imagination inflation exercise in which they either performed, imagined, or merely heard the 54 action statements. After the participants heard all 54 action statements, they were reminded of their two future in-lab sessions and dismissed.

Table 1. Study procedures.

Session 1
Study information sheet
Individual difference measures
Hear, imagine, or perform imagination inflation action statements
Session 2 (one week after Session 1)
Misinformation video
Filler task
Misinformation narrative
Filler task
Misinformation test
Imagine imagination inflation action statements
Session 3 (one week after Session 2)
DRM slideshow
DRM recognition test
Imagination inflation recognition test
Debriefing

Notes: The misinformation is paradigm was contained entirely in Session 2, the DRM paradigm was contained entirely in Session 3, and the imagination inflation paradigm spanned all three sessions. Subjects completed all individual difference questionnaires in Session 1.

Session 2 occurred exactly one week after Session 1, and all elements of Session 2 took place on the participants' individual computers. When participants first arrived, they completed the entire misinformation paradigm on the computer: they viewed the original event, completed the trivia-question filler task, read the narrative containing misinformation, worked on the math-problem filler task, and then completed the forced-choice recognition test about original event details. Upon completion, participants engaged in the second part of the imagination inflation procedure. During this time, 144 action statements appeared to participants one at a time on their computer screens. Participants were instructed that for each statement, they should take a few moments to close their eyes and imagine performing each action. After each imagination, participants provided a vividness rating for what was imagined to help ensure that they were imagining the actions. After participants completed these imaginations and their vividness ratings on their own time, they were reminded of their appointment for Session 3 and dismissed.

Participants returned for their third and final session exactly one week after Session 2. This session began with the DRM slideshow and recognition test. Immediately following the test, participants completed the final portion of the imagination inflation paradigm: a recognition test for the action statements presented during Session 1. All components of Session 3 were also completed on individual computers. At the completion of Session 3, participants were thanked for their time, fully debriefed on the purpose of the study, and awarded participation credit through the university's human subject pool.

Results

Attention check

Of the 367 participants who encountered the attention check, 21 did not pass. However, all study procedures

took place in the lab under the supervision of a research assistant, and their recognition memory in all three paradigms did not differ significantly from those who passed the check. Therefore, their data were included in all analyses.

False memories

The nature of this research requires a sufficient supply of memory distortions to be able to explore the relationships between them. To preview the findings, all three memory manipulations reliably produced false memories. Furthermore, all participants developed false memories of some kind. Of the 297 participants who completed the misinformation paradigm, only eight failed to falsely endorse any misinformation items. Of the 283 participants who completed the DRM, only two others did not falsely recognise any critical lures. Of the 244 participants who completed the imagination inflation exercise, only one other failed to judge any unheard but later imagined statements as heard.

The misinformation paradigm

Memory and confidence judgments. Participants were more accurate for control items ($M = .77$, $SD = .21$) than for items for which they were misled ($M = .40$, $SD = .27$), $t(296) = 19.18$, $p < .001$, Cohen's $d = 1.55$. Participants were equally confident, however, when making judgments for control items ($M = 4.25$, $SD = .66$) and misled items ($M = 4.19$, $SD = .74$), $t(296) = 1.26$, $p = .21$, $d = .14$. For every one of the eight critical items, participants were more accurate when it appeared for them as a control item than when it appeared for them as a misled item. A paired t-test revealed that overall, items were better remembered as controls than as misled items, $t(7) = 7.36$, $p < .001$, $d = 2.55$. Because there are only four misinformation items and four control items that are counterbalanced for each half of the participants, reliability estimates for these items were not calculated.

Source monitoring judgments. For each test item, participants indicated whether they remembered their answers from the video, the narrative, both, or neither. False memories of critical items combined with source misattributions to either the video or to both the video and the narrative constitute *robust* false memories. The proportions of robust false memories for misleading details in the misinformation condition ($M = .42$, $SD = .25$) is significantly higher than the proportion of the same source misattributions for falsely-endorsed misleading details in the control condition ($M = .15$, $SD = .16$), $t(292) = 15.65$, $p < .001$, $d = 1.30$. When robust false memories are calculated as proportions of all falsely remembered items, rather than out of all test items, the proportions are approximately equal between critical and control items $t(186) = .72$, $p = .47$, $d = .07$.

The Deese-Roediger-McDermott (DRM) paradigm

Recognition rates. The recognition rate for studied items was fairly high ($M = .68$, $SD = .20$) and that of distractor items fairly low ($M = .30$, $SD = .18$). Critical lures were falsely recognised at a fairly high rate as well ($M = .63$, $SD = .15$). Tests of within-subjects contrasts revealed a significant difference between recognition rates of critical and studied items, though the size of the effect is small, $F(1, 281) = 17.33$, $p < .001$, $\eta_p^2 = .06$. There was a strong, positive correlation between endorsement rates of studied items and critical lures, $r = .60$, $p < .001$, illuminating the associative nature of memory in this paradigm. However, there is a large and statistically significant difference between the mean recognition rates of critical and studied items combined and the recognition rate of distractor items, $F(1, 281) = 1219.77$, $p < .001$, $\eta_p^2 = .81$. Of the 15 DRM lists utilised, both the *king* and *mountain* lists produced the lowest endorsement rates of their critical lures ($M = .51$, $SD = .50$) while both the *sweet* and *window* lists produced the highest endorsement rate of their critical lures ($M = .79$, $SD = .41$). Internal consistency of recognition rates was $\alpha = .67$ for critical items (15 items), $\alpha = .82$ for studied items was (45 items), and $\alpha = .91$ for distractor items (60 items).

When participants indicated an item as studied at test, they were also asked to indicate whether they had an actual *memory* for having seen an item or mere *belief* that they had seen the item (but without any sense of a memory). Robust false DRM memories are defined as those false recollections of critical lures that are accompanied by a *memory* judgment. Of all critical lures presented at test, a sizeable minority of them were recognised robustly ($M = .20$, $SD = .16$), and this proportion is not statistically different from the proportion of studied items robustly recognised ($M = .20$, $SD = .12$; $t(277) = 1.06$, $p = .29$, $d = .07$). These data support the notion that judgments about critical lures are not simply based on criterion shifts but rather indeed represent actual memory distortion phenomena.

Confidence judgments. Participants were equally confident for their judgments about critical ($M = 3.23$, $SD = .69$) studied ($M = 3.23$, $SD = .66$), and distractor items ($M = 3.23$, $SD = .65$), Huynh-Feldt $F(1.63,453.73) = .05$, $p = .92$. Confidence within subjects for these three items is also highly correlated, adjusted multiple $r^2 = .91$. Adjusted multiple r^2 statistics were calculated using the following formula:

$$r_{z.xy} = \sqrt{\frac{r_{xz}^2 + r_{yz}^2 - 2r_{xz}r_{yz}r_{xy}}{1 - r_{xy}^2}}$$

The imagination inflation paradigm

Memory for having heard Session 1 statements. To understand how imagination during Session 2 affected memory for action statements presented in Session 1,

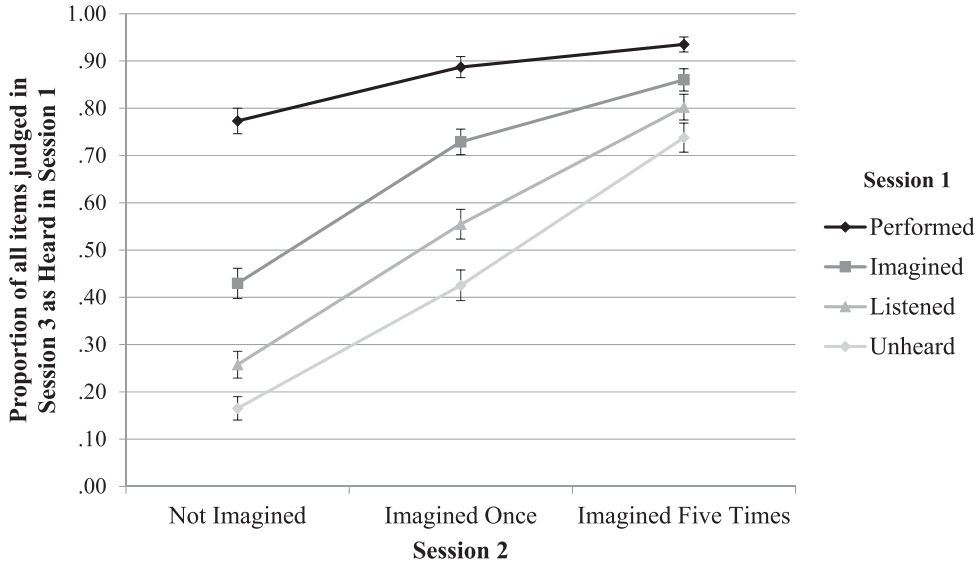

Figure 1. Mean rates of *Heard* judgments for imagination inflation items by Session 1 presentation type and Session 2 imagination type. Error bars represent 95% within-subjects confidence intervals.

participants' memories were tested during Session 3. Specifically, at test, participants were presented with a number of action statements (including those presented in Session 1 as well as some new, never-presented statements) and indicated whether they remembered hearing the statement during Session 1. They also provided a confidence judgment for their answer, again using a scale anchored at 1 (Not Confident) to 5 (Very Confident). Furthermore, if they did remember hearing the action statement, they were asked to indicate whether they performed, imagined, or only heard the action.

In order to analyze the memory data, each block of statements was first coded according to what the participant was instructed to do with it in Session 1 as well as the number of times that they imagined it in Session 2. This results in 12 categories of items at test; mean recognition rates for these items appear in Figure 1. A 4 (Session 1 Item Type) × 3 (Number of Imaginations in Session 2) repeated-measures ANOVA was then performed to gauge how often participants remembered having heard these items in Session 3. For the following analyses, wherever assumptions of sphericity are violated, Huynh-Feldt *F* statistics are reported.

There was a main effect of Session 1 Item Type: participants made correct *Heard* judgments most often to items they had performed in Session 1 ($M = .87$, $SD = .13$). Their rates of correct recognition were lower if they had imagined the item in Session 1 ($M = .67$, $SD = .16$) and lower still if they had merely heard the item in Session 1 ($M = .54$, $SD = .11$). Unheard items were recognised as heard least often ($M = .44$, $SD = .16$), Huynh-Feldt $F(2.83, 688.45) = 575.11$, $p < .001$, $\eta_p^2 = .70$. Furthermore, there was a main effect of imagination; statements that were not imagined at all in Session 2 were recognised less often ($M = .41$, $SD = .14$) than statements that were imagined once ($M = .65$, $SD = .15$) or five times ($M = .83$, $SD = .14$), Huynh-Feldt $F(1.87, 453.48) = 948.53$, $p < .001$, $\eta_p^2 = .80$. This relationship is further qualified by a significant interaction, Huynh-Feldt $F(1.87, 453.48) = 948.53$, $p < .001$, $\eta_p^2 = .80$. The effect of imagination, or the magnitude of the difference in memory for events between not imagining, imagining once, and imagining five times, was greatest for unheard statements. Moreover, a one-way repeated measures ANOVA revealed large differences in memory between non-imagined Session 1 statements, $F(3, 729) = 456.67$, $p < .001$, $\eta_p^2 = .65$. Those differences are smaller for those statements imagined once, $F(3, 729) = 257.48$, $p < .001$, $\eta_p^2 = .51$, though the difference still represents a large effect. For statements that were imagined five times, the effect is smaller yet, Huynh-Feldt $F(2.762, 671.19) = 64.47$, $p < .001$, $\eta_p^2 = .22$.

Confidence judgments for having heard Session 1 statements. Recall that participants provided a confidence rating for their judgments of whether or not they heard a particular statement during Session 1. A two-way repeated measures ANOVA was performed on confidence judgments, and this test reveals a significant effect of Session 1 Item Type, $F(3, 732) = 4.90$, $p = .002$, $\eta_p^2 = .02$. This effect is small, though post-hoc analyses (Helmert contrasts) indicate that confidence for unheard statements was significantly lower than for the other types of statements combined, $F(1, 244) = 13.17$, $p < .001$, $\eta_p^2 = .05$. However, there was no effect of Session 2 imagination condition ($p = .22$) or interaction of item type by imagination ($p = .84$) on confidence ratings. In other words, across all Session 1 item types, memory judgments for actions were made with equal confidence regardless of whether they were not imagined, imagined once, or imagined five times. Furthermore, the range of confidence judgments for all 12 item types (all 12 cell means) is small; these scores range from 3.73 to 3.87 on a 5-point scale.

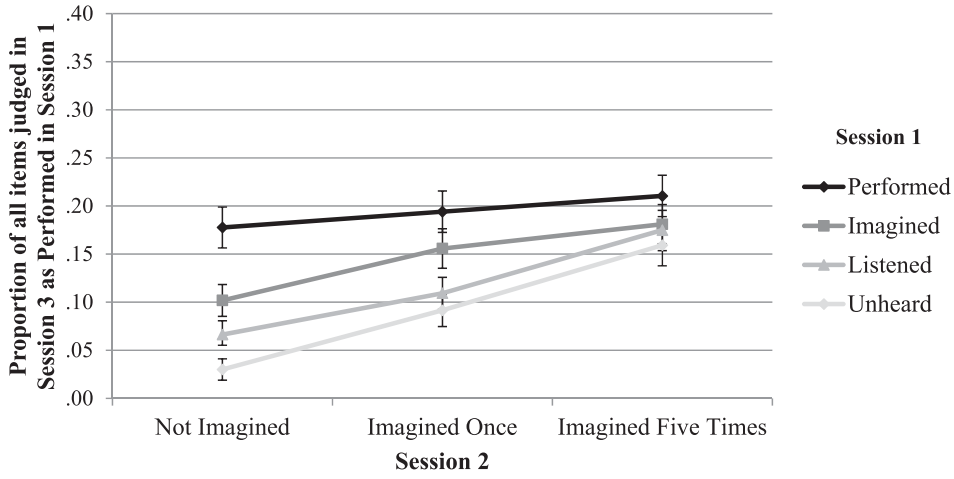

Figure 2. Mean rates of *Performed* judgments for imagination inflation items by Session 1 presentation type and Session 2 imagination type. Error bars represent 95% within-subjects confidence intervals.

Memory for having performed Session 1 statements. Participants who responded during Session 3 that they had indeed heard a statement during Session 1 were also asked to indicate whether they remembered performing, imagining, or merely listening to that statement during Session 1. Items judged as performed are depicted in Figure 2, and the pattern of data is similar to the proportion of remembered statements. Another 4 (Session 1 Item Type) × 3 (Number of Imaginations in Session 2) repeated-measures ANOVA revealed a main effect of Session 1 Item Type on the proportion of remembered items deemed performed, Huynh-Feldt $F(2.81, 684.79) = 65.21$, $p < .001$, $\eta_p^2 = .21$, and a main effect of imagination, Huynh-Feldt $F(1.85, 448.22) = 90.25$, $p < .001$, $\eta_p^2 = .27$. Again, a significant interaction was also found, Huynh-Feldt $F(5.60, 1360.36) = 6.03$, $p < .001$, $\eta_p^2 = .02$.

It is worth noting that with zero imaginings, participants reported actually having performed statements that they did not even hear 3.01% of the time. This percentage increases to 9.16% of the time for unheard statements that were imagined once and increases even higher to 15.90% of the time for unheard statements that were imagined five times. This difference is statistically significant, Huynh-Feldt $F(2.04, 410.44) = 69.94$, $p < .001$, $\eta_p^2 = .22$. These memories are perhaps most impressive in that participants claim to have heard *and* performed actions – like stacking checkers or faking sneezes – that they never even heard.

Inter-paradigm relationships

In order to understand one's propensity to develop false memories across multiple tasks, correlations were analysed between all three false memory tasks. Each of these relationships is described separately below.

The misinformation and DRM paradigms

Both tasks produced two measures of false memory. In the misinformation task, these measures are the proportion of misinformation items recognised at test after having encountered those items in the post-event narrative and the proportion of these items that were robustly recognised (i.e., that were recognised and that were accompanied by a judgment of having seen the item in either the video or the video and the narrative). In the DRM, these measures include the proportion of critical lures falsely recognised and the proportion of critical lures that are robustly recognised (i.e., that are accompanied by a *Memory* judgment). Correlations between these measures appear in Table 2. There is a significant positive correlation between the endorsement rate of critical lures in the DRM and both the proportion of misinformation items endorsed, $r = .14$, $p = .03$, as well as the proportion of misinformation items robustly endorsed, $r = .17$, $p = .01$. There are only trend-level relationships, however, between the proportion of robustly recognised critical lures and both the proportion of misinformation items endorsed, $r = .11$, $p = .09$, and the proportion of misinformation items robustly endorsed, $r = .11$, $p = .08$.

The misinformation and imagination inflation paradigms

Both false memory measures in the misinformation paradigm were correlated with multiple false memory

Table 2. Pearson R correlations between false memory measures in the misinformation and DRM paradigms.

	Misinformation measures	
DRM measures	Proportion of misinformation items recognised	Proportion of misinformation items robustly recognised
Proportion of critical lures recognised	**0.14***	**0.17****
Proportion of critical lures robustly recognised	0.11†	0.11†

Note: Correlations in bold are statistically significant at $p < .05$ or smaller. †$p < .10$; *$p < .05$; **$p < .01$.

Table 3. Pearson R correlations between false memory measures in the misinformation and imagination inflation paradigms.

	Misinformation measures	
Imagination inflation measures	Proportion of misinformation items recognised	Proportion of misinformation items robustly recognised
Proportion of *Heard* judgments for unheard items in Session 1		
Items imagined once in Session 2	−0.01	0.00
Items imagined five times Session 2	**0.14***	0.11†
Items imagined at all in Session 2	0.08	0.07
Proportion of *Performed* judgments for non-performed items in Session 1		
Items unheard in Session 1		
Items imagined once in Session 2	−0.04	−0.12†
Items imagined five times Session 2	0.00	−0.02
Items imagined at all in Session 2	−0.02	−0.09
Items listened-to in Session 1		
Items imagined once in Session 2	−0.01	0.04
Items imagined five times Session 2	0.04	**0.15***
Items imagined at all in Session 2	0.02	**0.13***
Items imagined in Session 1		
Items imagined once in Session 2	0.08	0.08
Items imagined five times Session 2	0.07	0.04
Items imagined at all in Session 2	0.10	0.08

Note: Correlations in bold are statistically significant at $p < .05$ or smaller.
†$p < .10$; *$p < .05$.

measures in the imagination inflation paradigm. Namely, false memories of interest include *Heard* judgments to statements unheard in Session 1 but imagined in Session 2 as well as *Performed* judgments to statements that were unheard, merely listened to, or imagined in Session 1 and later imagined in Session 2. The results of the correlations of these measures to misinformation false memory measures appear in Table 3. It is worth noting that correlations involving imagination inflation items that were imagined "at all" represent a collapse across items imagined once and items imaged five times.

There is a significant positive correlation between the proportion of misinformation items recognised and the proportion of *Heard* judgments for unheard items in Session 1 that were imagined five times in Session 2, $r = .14$, $p = .03$. When the misinformation variable in this relationship is the proportion of robustly recognised items, the correlation remains positive but only at a trend level of significance, $r = .11$, $p = .08$. There is also significant, positive correlation between the proportion of misinformation items robustly recognised and the proportion of *Performed* judgments to items listened to in Session 1 and imagined five times in Session 2, $r = .15$, $p = .02$. This relationship holds when the imagination variable represents listened-to statements that are imagined either once or five times, $r = .13$, $p = .04$. However, there is also a trend-level negative relationship between the proportion of misinformation items robustly recognised and the proportion of *Performed* judgments to unheard items in Session 1 that were imagined once in Session 2, $r = -.12$, $p = .06$.

The DRM and imagination inflation paradigms

Both false memory measures in the DRM paradigm were correlated with the same false memory measures in the imagination inflation paradigm described above. These correlations appear in Table 4. The proportion of critical lures falsely recognised correlates significantly with the proportion of *Performed* judgments to items listened to in Session 1 and imagined five times in Session 2, $r = .17$, $p = .01$. This relationship holds when the imagination variables includes listened-to items that were imagined at all, $r = .16$, $p = .02$.

When examining the relationships between imagination inflation false memories and *robustly* recognised critical lures, additional significantly positive associations emerge. For example, the proportion of robustly recognised critical lures is positively correlated with the proportion of *Heard* judgments for unheard statements in Session 1 that are imagined once, $r = .13$, $p = .04$, imagined five times, $r = .13$, $p = .04$, or imagined at all $r = .17$, $p < .01$. Furthermore, robustly recognised lures are correlated with the proportion of *Performed* judgments to unheard items in Session 1 and imagined once in Session 2, $r = .17$, $p < .01$. For items that are merely listened-to in Session 1, robustly recognised critical lures are associated with *Performed* judgments to these items when they are imagined once, $r = .17$, $p = .01$, or imagined at all, $r = .19$, $p < .01$; this relationship approaches significance when these items are imagined five times, $r = .12$, $p = .05$. Finally, for items that are imagined in Session 1, robustly recognised critical lures are associated with *Performed* judgments to these items when they are imagined once, $r = .14$, $p = .03$, and imagined at all, $r = .13$, $p = .04$.

Confidence

Participants rated their confidence on a scale of 1 (Not Confident) to 5 (Very Confident) for their DRM recognition judgments, judgments for misinformation test items and judgments of whether a particular imagination inflation item was heard or not (note that confidence was not assessed for judgments about whether an item deemed

Table 4. Pearson R correlations between false memory measures in the DRM and imagination inflation paradigms.

	DRM measures	
Imagination inflation measures	Proportion of critical lures recognised	Proportion of critical lures robustly recognised
Proportion of *Heard* judgments for unheard items in Session 1		
Items imagined once in Session 2	0.04	**0.13***
Items imagined five times Session 2	0.10	**0.13***
Items imagined at all in Session 2	0.09	**0.17****
Proportion of *Performed* judgments for non-performed items in Session 1		
Items unheard in Session 1		
Items imagined once in Session 2	0.01	**0.17****
Items imagined five times Session 2	−0.02	0.00
Items imagined at all in Session 2	−0.01	0.09
Items listened-to in Session 1		
Items imagined once in Session 2	0.04	**0.17****
Items imagined five times Session 2	**0.17****	0.12†
Items imagined at all in Session 2	**0.16***	**0.19****
Items imagined in Session 1		
Items imagined once in Session 2	0.03	**0.14***
Items imagined five times Session 2	0.05	0.05
Items imagined at all in Session 2	0.05	**0.13***

Note: Correlations in bold are statistically significant at $p < .05$ or smaller.
†$p < .10$; *$p < .05$; **$p < .01$.

heard in Session 1 was performed, imagined, or merely listened-to at that time). There is a trend-level positive correlation between confidence for misinformation items and confidence for critical lures, $r = .11$, $p = .09$, and a significant positive correlation between confidence for misinformation items and confidence for unheard, imagined items, $r = .19$, $p < .01$. A strong positive correlation exists between confidence for critical lures and confidence judgments for unheard, imagined items, $r = .59$, $p < .001$. All three confidence judgments are also positively correlated, adjusted multiple $r^2 = .15$.

Individual differences

Table 5 contains descriptive statistics for the demographic and personality variables measured in this investigation. These descriptives include the number of observations, the minimum and maximum scores, the mean and standard deviation, the skewness and kurtosis, and Cronbach's alpha (where relevant) of each variable. The relationships of these variables to memory phenomena are first discussed within the context of each paradigm.

The misinformation paradigm

Correlational analyses were conducted to examine which relationships, if any, exist between demographic/personality variables and memory measures in the misinformation paradigm. These Pearson R correlations appear in Table 6. As this table shows, there are no significant individual difference correlates with either overall or robust false memory. However, three personality scales are associated with confidence judgments for misinformation items: conscientiousness ($r = .19$, $p < .001$), Need for Cognition ($r = .12$, $p = .04$), and dissociative experiences ($r = -.16$, $p = .01$). Discrimination scores of the Over-claiming Questionnaire are positively associated with accuracy for control items in the misinformation task ($r = .13$, $p = .03$), but no other individual difference variables predict overall accuracy, robust accuracy, or confidence judgments for control items.

The DRM paradigm

Correlations were examined between the same individual difference variables and measures of memory in the DRM task. Several more relationships emerge for the DRM than for the misinformation paradigm; these correlations appear in Table 7. Specifically, total false recognition of critical lures is associated with the Cognitive Reflection Task (CRT) in terms of both the number of intuitive answers given in the task ($r = .25$, $p < .001$) and the number of correct answers given to the task ($r = -.20$, $p = .001$). The number of correct answers given to the CRT is also associated with a decrease in robustly recognised critical lures ($r = -.12$, $p = .04$). A higher score on the Anomalous/Paranormal Experience Subscale of the Anomalous Experiences Inventory (AEI), on the other hand, is associated with increase in robustly recognised lures ($r = .13$, $p = .04$). In terms of confidence judgments for critical lures, only OCQ discrimination scores are associated such judgments ($r = -.23$, $p < .001$).

When examining veridical memory, overall recognition of studied items was associated only with the sum of intuitive answers given to the CRT ($r = .13$, $p = .03$). Robustly recognised studied items are correlated only with the Creative Experiences Questionnaire ($r = .12$, $p = .04$). Confidence judgments for studied items, on the other hand, is associated with OCQ discrimination scores ($r = -.21$, $p < .001$), absorption ($r = .13$, $p = .03$), and religiosity ($r = .13$, $p = .03$).

The imagination inflation paradigm

As was calculated for the DRM, correlations were computed between measures of memory in the imagination inflation paradigm and individual difference variables of interest; these correlations appear in Table 8. For the sake of

Table 5. Descriptive statistics for demographic and personality measures.

Measure	*N*	Min	Max	*M*	*SD*	Skewness	Kurtosis	Cronbach's *α*
Age	367	18.00	55.00	20.77	3.64	4.27	27.66	–
Proportion of life speaking English	360	.10	1.00	0.90	0.19	−2.20	4.60	–
Estimated GPA	342	.50	4.50	3.11	0.59	−0.55	0.55	–
Big Five – Extraversion	365	1.00	6.00	3.37	0.82	−0.18	−0.20	0.86
Big Five – Agreeableness	365	2.13	6.00	3.88	0.59	−0.26	−0.03	0.71
Big Five – Conscientiousness	365	1.89	6.00	3.64	0.65	0.09	−0.09	0.77
Big Five – Neuroticism	365	1.00	6.00	3.10	0.83	−0.03	−0.15	0.84
Big Five – Openness	365	1.60	6.00	3.51	0.61	−0.06	0.66	0.76
OCQ – Discrimination	366	−2.52	3.37	0.00	1.00	0.18	0.00	–
OCQ – Bias	366	−2.70	2.17	0.00	1.00	−0.52	0.16	–
NFC	364	24.00	125.00	80.09	18.20	−0.08	0.04	0.86
FI	365	28.00	84.00	57.94	11.11	−0.23	−0.16	0.85
CRT – Sum of Intuitive Answers	364	0.00	3.00	2.05	1.02	−0.71	−0.71	–
CRT – Sum of Correct Answers	364	0.00	3.00	0.59	0.89	1.38	0.84	–
VVIQ	365	1.81	5.00	3.80	0.68	−0.40	−0.46	0.95
DES	365	0.00	100.00	29.94	16.89	0.62	0.51	0.94
TAS	363	2.00	51.00	17.12	8.30	0.72	0.65	0.87
CEQ	364	0.00	22.00	9.26	4.44	0.10	−0.41	0.76
AUROS	334	10.00	100.00	52.11	16.33	−0.36	−0.70	0.91
AEI	364	0.00	20.00	4.97	3.31	1.34	2.71	–

parsimony, false memories are represented in these analyses through only two variables. The first is the proportion of *Heard* judgments to statements unheard in Session 1 and imagined at all in Session 2 (collapsed across statements imagined once and statements imagined five times). The second is the proportion of *Performed* judgments to statements that were not performed in Session 1 (collapsed across unheard, listened-to, and imagined statements) and imagined at all in Session 2 (again collapsed across statements imagined once and statements imagined five times). True memories were assessed through two similarly constructed variables. The first is *Heard* judgments to statements that were heard in Session 1 (collapsed across listened-to, imagined, and performed statements) and not imagined in Session 2. The second is *Performed* judgments to statements that were performed in Session 1 and not imagined in Session 2. Accurate memories operationalised this way are most akin to memory accuracy for control items in the misinformation paradigm.

In terms of false memory, several individual difference measures were correlated with both false *Heard* judgments and *Performed* judgments after imagination. These includes trait agreeableness (*Heard*: $r = -.14$, $p = .03$; *Performed*: $r = -.14$, $p = .03$), OCQ Bias scores (*Heard*: $r = -.14$, $p = .03$; *Performed*: $r = -.18$, $p < .01$), and dissociative experiences (*Heard*: $r = .13$, $p < .05$; *Performed*: $r = .20$, $p < .01$). Furthermore, false *Performed* judgments are also associated with absorption ($r = .15$, $p = .02$) and anomalous experiences ($r = .13$, $p < .05$). Confidence judgments for

Table 6. Pearson R correlations between demographic and personality variables and misinformation variables.

	Misinformation items			Control items		
Measure	Overall false memory	Robust false memory	Confidence	Overall veridical memory	Robust veridical memory	Confidence
Age	−0.03	0.01	0.03	0.07	−0.04	0.09
Proportion of life speaking English	0.01	0.03	0.05	0.09	−0.08	−0.06
Estimated GPA	−0.08	0.04	0.09	0.00	−0.02	−0.02
Big Five – Extraversion	0.04	0.06	0.07	0.04	0.03	0.04
Big Five – Agreeableness	−0.01	0.01	0.06	0.00	0.00	−0.05
Big Five – Conscientiousness	0.04	0.09	**0.19*****	−0.01	0.05	0.06
Big Five – Neuroticism	0.04	−0.03	−0.04	−0.07	−0.01	−0.04
Big Five – Openness	0.05	0.04	0.00	0.00	0.04	−0.04
OCQ – Discrimination	−0.10	−0.03	0.05	**0.13***	−0.07	0.00
OCQ – Bias	0.01	0.08	0.05	0.07	−0.01	−0.01
NFC	−0.10	−0.01	**0.12***	0.00	0.04	0.04
FI	0.01	−0.01	0.03	0.01	−0.01	−0.01
CRT Intuitive Answers	0.06	0.06	0.04	0.00	0.03	0.04
CRT Correct Answers	−0.07	−0.05	0.03	0.07	−0.08	0.00
VVIQ	−0.02	0.06	0.02	−0.01	−0.02	0.06
DES	0.01	−0.06	**−0.16****	−0.09	0.03	−0.09
TAS	−0.01	−0.06	−0.11	−0.08	0.01	−0.02
CEQ	0.07	0.03	−0.07	−0.08	0.06	−0.02
AUROS	0.10	0.07	0.03	−0.02	0.00	−0.05
AEI	0.07	−0.02	−0.05	−0.03	0.00	−0.06

Note: Correlations in bold are statistically significant at $p < .05$ or smaller.
*$p < .05$; **$p < .01$; ***$p < .001$.

Table 7. Pearson R correlations between demographic and personality variables and DRM variables.

	Critical lures			Studied items		
Measure	Overall false memory	Robust false memory	Confidence	Overall veridical memory	Robust veridical memory	Confidence
Age	−0.06	0.07	−0.10	−0.05	−0.03	−0.08
Proportion of life speaking English	0.10	0.06	−0.09	0.01	0.01	−0.07
Estimated GPA	−0.10	−0.03	−0.09	−0.10	−0.04	−0.12
Big Five – Extraversion	−0.02	0.08	0.02	0.03	0.05	0.02
Big Five – Agreeableness	−0.03	−0.08	0.10	−0.02	−0.03	0.09
Big Five – Conscientiousness	−0.01	−0.01	0.07	0.02	−0.06	0.08
Big Five – Neuroticism	0.08	0.02	0.00	0.10	0.02	−0.03
Big Five – Openness	−0.06	0.01	−0.01	−0.03	0.03	0.00
OCQ – Discrimination	−0.05	−0.05	**−0.23****	−0.02	−0.07	**−0.21*****
OCQ – Bias	0.04	−0.02	0.02	0.01	−0.07	0.04
NFC	−0.07	−0.04	−0.07	−0.05	−0.04	−0.09
FI	−0.02	0.10	0.05	−0.01	0.11	0.08
CRT Intuitive Answers	**0.25*****	0.09	0.01	**0.13***	0.09	0.01
CRT Correct Answers	**−0.20****	**−0.12***	−0.03	−0.06	−0.11	−0.04
VVIQ	−0.02	0.10	0.09	−0.02	0.10	0.05
DES	−0.06	−0.02	0.02	−0.02	−0.01	0.05
TAS	−0.05	0.02	0.09	0.00	0.08	**0.13***
CEQ	0.08	0.02	0.03	0.09	**0.12***	0.06
AUROS	0.06	0.11	0.11	0.05	0.07	**0.13***
AEI	0.01	**0.13***	0.03	0.02	0.11	0.05

Note: Correlations in bold are statistically significant at $p < .05$ or smaller.
*$p < .05$; **$p < .01$; ***$p < .001$.

unheard, later imagined statements is associated with both OCQ discrimination ($r = -.15$, $p = .02$) and OCQ bias ($r = .13$, $p = .04$).

In the absence of any imagination, accurate *Heard* judgments are associated with OCQ bias ($r = -.21$, $p = .001$) and dissociative experiences ($r = .14$, $p = .03$). Accurate *Performed* judgments are also positively associated with dissociative experiences, ($r = .13$, $p = .04$). Confidence for items that were heard but not imagined is associated with estimated GPA ($r = -.16$, $p = .02$), OCQ discrimination ($r = -.17$, $p < .01$), Faith in Intuition ($r = .17$, $p < .01$), religiosity ($r = .19$, $p < .01$), and anomalous experiences ($r = .13$, $p < .05$).

Discussion

Inter-paradigm relationships

We assessed overall and robust false memories in the misinformation paradigm, overall and robust false memories in the DRM, and false *Heard* and false *Performed* judgments to several items in the imagination inflation task. Small but statistically significant correlations emerged between some false memory variables in each of the three comparisons. Every significant correlation is positive, but again, they are typically rather modest: Pearson R coefficients range from $r = .14$ to $r = .17$ between false memories in

Table 8. Pearson R correlations between demographic and personality variables and imagination inflation variables.

	False memories			True memories		
Measure	Heard judgments	Performed judgments	Confidence	Heard judgments	Performed judgments	Confidence
Age	0.04	0.06	0.03	−0.08	0.00	−0.06
Proportion of life speaking English	−0.05	−0.04	−0.02	0.01	−0.01	−0.08
Estimated GPA	−0.01	−0.10	−0.09	−0.07	0.01	**−0.16***
Big Five – Extraversion	−0.06	0.01	0.01	0.07	−0.03	0.08
Big Five – Agreeableness	**−0.14***	**−0.14***	0.08	−0.09	−0.04	0.07
Big Five – Conscientiousness	−0.06	−0.01	0.09	−0.05	−0.11	0.05
Big Five – Neuroticism	0.06	0.04	−0.04	0.00	−0.01	0.04
Big Five – Openness	−0.03	0.04	0.01	0.04	−0.03	0.03
OCQ – Discrimination	0.04	−0.05	**−0.15***	−0.02	−0.09	**−0.17****
OCQ – Bias	**−0.14***	**−0.18****	**0.13***	**−0.21****	−0.08	0.08
NFC	0.00	−0.05	−0.03	0.04	−0.10	−0.04
FI	0.00	0.04	0.08	−0.05	0.02	**0.17****
CRT Intuitive Answers	0.03	−0.08	0.09	−0.03	−0.05	0.05
CRT Correct Answers	0.04	0.00	−0.12	0.03	−0.01	−0.02
VVIQ	0.00	−0.03	0.04	−0.04	0.00	0.09
DES	**0.13***	**0.20****	0.02	**0.14***	**0.13***	0.03
TAS	0.06	**0.15***	0.11	0.07	0.04	0.12
CEQ	0.03	0.08	0.11	0.05	0.09	0.11
AUROS	−0.02	0.12	0.12	−0.01	0.00	**0.19****
AEI	0.12	**0.13***	0.06	0.00	0.05	**0.13***

Note: Correlations in bold are statistically significant at $p < .05$ or smaller.
*$p < .05$; **$p < .01$; ***$p < .001$.

the misinformation paradigm and DRM (consistent with Zhu et al., 2013), $r = .13$ to $r = .15$ between misinformation false memories and imagined false memories, and from $r = .13$ to $r = .19$ between false memories in the DRM and imagined false memories.

Concerning the misinformation and imagination inflation tasks, correlations emerged between total false misinformation memories and false *Heard* judgments to items unheard but imagined five times as well as between robust false misinformation memories and false *Performed* judgments to items listened-to in Session 1 and later imagined once or five times. False memories in both paradigms may arise from source monitoring failures through external suggestion (misinformation) or direction (imagination). Though speculative, this could account for the positive correlations revealed here. However, the number and magnitude of these three correlations should not be overstated; the 21 other possible correlations between false memories are not significant.

Other correlations emerged between DRM false memories and imagined false memories. Specifically, total false recognition of lures was associated with *Performed* judgments to items listened to in Session 1 and later imagined. Robustly remembered lures, on the other hand, were associated with false *Heard* judgments and false *Performed* judgments across every major category of item (see Table 4). Because robustly recognised lures are those for which participants report an actual memory of having seen the item, rather than a mere belief that they saw it, these particular memories are better explained by activation-monitoring theories than are total false recognition of the lures. Source monitoring failures also likely account for false memories arising from imagination inflation; participants may develop these memories when they cannot accurately identify the source of their memory as their Session 2 imagination instead of that which occurred in Session 1. From a monitoring perspective, therefore, it is not surprising to find more relationships between imagined memories and robust false recognition of lures than imagined memories and total false recognition of lures. However, a test of shared monitoring failures amongst the paradigms was not a component of this study.

Remarkably, confidence judgments for false memory items in all three paradigms were correlated. These correlations are small between judgments for misinformation items and both critical lures and imagination items, but the correlation between confidence judgments for critical lures and imagined items was strikingly large ($r = .59$). The correlation between confidence for studied items in the DRM and heard but unimagined items in the imagination inflation paradigm was also correlated, though to a far lesser degree. The most obvious similarities between DRM judgments and imagination inflation judgments are that they involve a yes-no recognition test, while the misinformation paradigm does not, and both tests occurred during Session 3 while the misinformation paradigm took place entirely in Session 2. It could be the case that a global sense of confidence during Session 3 affected feelings of certainty for memory judgments, and perhaps if the misinformation test was also given in Session 3, the correlations between confidence judgments for misinformation items would be stronger.

It is no surprise that these correlations are small for some comparisons and altogether absent in many of the others. Several distinctions between the paradigms help to explain limits of inter-paradigm relationships. DRM false memories are the result of spontaneous internal processes, misinformation memories arise through external suggestion, and imagination inflation develops when what was imagined confounds what was real. Imagination-inflated memories are autobiographical in nature, whereas misinformation memories concern an external event, and the DRM produces false memories more so through semantic rather than episodic memory stores. The DRM also spans two crucial phases (encoding and test) while the misinformation and imagination paradigms span three (encoding, suggestion/imagination, and test). These tasks are quite different in terms of their methods but also in how they are ultimately experienced by the participant. When considering whether some people may have a "false memory trait", it is important also to consider that the dissimilarities between these paradigms may simply trump the fact that they all produce false memories of one kind or another (consistent with Bernstein et al.'s [2018] article title, "'False Memory' is a linguistic convenience").

Individual differences

A large number of individual differences were examined in this study as potential predictors of false memories. As the number of comparisons increases, so too does the probability of committing Type I errors (false positive correlations). Nevertheless, relatively few of these measures predict memory – veridical or illusory – in the three paradigms. When taken together in an ordinary least squares multiple regression analysis, the 19 predictors do not account for a significant amount of the variance in the proportion of misinformation items recognised ($p = .61$) critical lures recognised ($p = .09$), or false *Heard* judgments to unheard, imagined items ($p = .33$), despite large sample sizes for each paradigm ($n = 244$–297 after attrition) and no problems with collinearity or residual diagnostics. Therefore, each of the predictors is discussed in the context of individual paradigms.

In the misinformation task, there are zero significant individual difference correlates of false memory. These include failures to replicate relationships founds in the literature between misinformation false memories and vividness of visual imagery, the agreeableness and openness subscales of the Big Five personality inventory, and dissociative experiences. This may be due in part to methodological and analytical differences between the reported

studies and this one. For example, Tomes and Katz (1997) compared Vividness of Visual Imagery Questionnaire scores between participants who endorsed all three misinformation items in their design to those who endorsed fewer than three misinformation items. Though dichotomisation of continuous variables may reveal group differences where none exist in correlational analyses, there are several limits of this approach that result in more liberal analysis (Irwin & McClelland, 2003; Maxwell & Delaney, 1993). Furthermore, Eisen and Carlson (1998) report significant positive correlations between misinformation errors and both dissociative experiences and absorption, but these correlations are significant at the $p < .05$ level only with one-tailed tests. All analyses conducted in this investigation were calculated with two-tailed tests given adequate statistical power to detect differences (i.e., post-hoc power analyses revealed Power [1 – β error] = .99 to detect a medium-sized correlation between absorption and misinformation errors in this study).

In the DRM, the Cognitive Reflection Task is most highly correlated with the proportion of lures falsely remembered. More specifically, the total sum of intuitive answers is positively correlated with false memories while the total sum of correct answers is negatively correlated. These relationships may be explained by the fact that the CRT is designed to lure respondents into providing an intuitive but incorrect answer, much in the way that the DRM is designed to lure respondents into endorsing intuitive but never presented critical items at test. Conversely, the ability to suppress an intuitive, System 1 (Stanovich & West, 2000) thought process to arrive at correct answer in the CRT may be related to the ability to resist endorsement of a critical lure. Frederick (2005) also describes his CRT as a test that requires cognitive ability in order to generate correct answers; the negative correlation between correct answers and critical lures is therefore compatible with findings that suggest cognitive ability, measured through a variety of tasks, is negatively correlated with false memories in the DRM (Zhu et al., 2010b). Surprisingly, OCQ discrimination (a proxy for cognitive ability in this study) is not significantly associated with false memories. Research has shown that working memory capacity is somewhat protective against the development of DRM errors (Watson et al., 2005), but discrimination scores on the OCQ discrimination depend on a subject's familiarity with pieces of general, trivial-like knowledge rather than working memory capabilities.

Finally, one's propensity to develop false memories after imagination is correlated with a few of the individual difference variables. For example, both an increase in false *Heard* and false *Performed* judgments are associated with a decrease in agreeableness. Though some have decried misinformation effects as an acquiescence to demand characteristics or others social pressures (McCloskey & Zaragoza, 1985), this finding does not support that claim. False *Heard* and false *Performed* judgments are also associated with a decrease in OCQ bias scores and an increase in dissociativity. This latter relationship confirms the results of previous studies (Heaps & Nash, 1999; Hyman & Billings, 1998). False *Performed* judgments here are also associated with absorption and anomalous experiences. Absorption has been shown to be associated with an increase in more naturally occurring false autobiographical memories (Platt et al., 1998), and those who are more prone to absorption in their environments may be more suggestible in a variety of contexts, imagination inflation notwithstanding. Those who report having more anomalous experiences may also be prone to developing false autobiographical memories because the anomalous experiences they report may themselves be confabulations. Interestingly, anomalous experiences are associated only with false *Performed* judgments, not with false *Heard* judgments; perhaps reports of events that are as extreme and unlikely as those listed in the AEI (e.g., "At times, I have felt possessed by an outside force") are associated only with reports as extreme and unlikely as performing an action statement that was not even encountered in Session 1.

To summarise, several individual difference variables were investigated as predictors of false memory in the misinformation, DRM, and imagination inflation paradigms. Very few are significantly correlated with false memories, and those that did correlate represent small and small-to-medium sized effects. The only common predictor to false memories in multiple paradigms is one's report of anomalous experiences, and this predicts both robust false memories in the DRM and false *Performed* judgments to unheard, imagined items in the imagination inflation paradigm to the same degree ($r = .13$). The relative inability of these variables to predict false memories is consistent with the Dual Encoding Interference hypothesis (Patihis, 2018). This hypothesis posts that in a misinformation task, traits that enhance encoding will support encoding of both true and false memories. Similarly, traits that weaken encoding will result in both weak misinformation memory and weak memory for original event details. Both types of traits will produce a moderate probability of false memory that might be akin to someone that possess neither high nor very low amounts of the trait, resulting in a null correlation. This may be particularly applicable to other false memories involving source monitoring failures like those arising from imagination inflation. The relevance of this hypothesis to DRM false memories is limited, however, as DRM lures are not encoded at the time of study.

Practical implications

If it is the case that we are all vulnerable to memory distortion, then this has important implications for both clinical and legal practitioners. In a court case, for example, an expert witness (whom we will call Dr. B) denounced the idea that an alleged abuse victim was likely to have experienced false memories about her abuse given her low

scores on the Gudjonsson Suggestibility Scale (*Doe v. Hartford Roman Catholic*, 2014). This scale (Gudjonsson, 1984) employs a misinformation-type methodology, with an original event described in a narrative, to gauge how willing people are both to yield to suggestive questions and to shift their initial responses in the face of social pressure. To date, there is no published evidence to indicate that scores on this scale predict other types of false memories, just as misinformation false memories are not strongly correlated with DRM or imagination false memories in this study. A clinician who wishes to follow Dr. B's approach, however, may feel liberty to employ a controversial therapeutic technique because his or her client has a low GSS score, recognises relatively few critical DRM lures, does not seem to incorporate imaginations into her memory for actual events, or through other tests, does not *seem* to produce false memories to a large degree. This hypothetical situation is reckless if not completely dangerous. Trial outcomes may be unfairly influenced and people's memories may be outright damaged by practices that remain wholly unsupported by science.

Strengths, limitations and future directions

This study benefits from a very large sample size for a study whose procedures occurred in the laboratory spanning three separate sessions over two entire weeks. Fortunately, the three paradigms utilised here produced false memories as expected. This, in conjunction with the large sample size, minimises the likelihood that null correlations are the result of Type II (false negative) errors. This within-subjects false memory study also includes imagination inflation as a measure of verifiable, false autobiographical memory. It is the first to suggest minimal to nonexistent relationships between imagined false memories and misinformation and DRM false memories. Unlike uncorroborated false memories arising from some types of false event suggestion, the false memories in this study are fully known to be false and therefore offer a methodological advantage. Finally, whether a false memory trait exists should be addressed not just by examining relationships between false memories themselves, but also by identifying other factors that represent shared variance among them. This multiple paradigms study also includes the largest battery of individual difference predictors to date.

However, limitations of this study must be addressed. First, memory assessment varies among the three paradigms. For example, the misinformation test contained two-alternative, forced-choice recognition questions while the DRM and imagination inflation test items required yes-no recognition judgments. The misinformation tests lacked a third alternative: a novel item that was not presented in either the original event nor in the misinformation narrative. The absence of this item may have slightly inflated the misinformation effect, but more importantly, similar control items were present in the both the DRM (distractor items) and the imagination inflation paradigm (unheard, unimagined items). This study lacks the ability to compare endorsement rates of novel items among all three paradigms. In a similar vein, the imagination inflation test did not contain a measure of robust false memory such as the source judgments for misinformation items or, more relevant to imagination inflation, remember/know judgments for DRM items. This limits to ability to interpret any false heard, listened, or performed judgment as arising from false memory rather than false belief and prevents comparing memories with more recollective qualities across all *three* tasks.

Another limitation of this study is that participants did not have the opportunity to provide open-ended responses. This means that information about the participants' recollective experiences is limited to remember/know judgments for DRM items and performed/imagined/listened-to judgments for imagined items that were judged as *Heard*. Information about a rememberer's subjective experiences is central component of false memory theories, and some have claimed that false memories cannot be entirely understood without considering them (Lampinen, Neuschatz, & Payne, 1997). Future research would benefit from allowing participants to freely describe their subjective phenomenology in multiple paradigms; content analysis could then shed light on how experience allows researchers to describe all three memory phenomena as *false memory* but also help elaborate upon the small to null relationships discovered in this research.

Another issue concerns the internal reliability of composite measures used in this study. It is possible that relationships between variables are not detected to the extent that that the variables themselves do not have high internal reliability (Spearman, 1904). While internal consistency was sufficient for the individual difference measures (see Table 5) and DRM memories ($\alpha = .67$ for critical items, $\alpha = .82$ for studied items $\alpha = .91$ for distractor items), reliability estimates for false memories in the misinformation and imagination inflation tasks could not be calculated due to item counterbalancing. However, the reliabilities reported here are comparable or higher to those reported by Ost et al. (2013), who noted that attenuation due to limited reliability would have rendered the correlations smaller but still discoverable.

In addition to addressing these limitations, future research may benefit from addressing the question of trait susceptibility through other psychological lenses. One of these is the use of neuroimaging. Functional MRI (fMRI) studies have demonstrated meaningful patterns of brain activity for true and false memories in both the misinformation paradigm (Baym & Gonsalves, 2010; Okado & Stark, 2005; Stark, Okado, & Loftus, 2010) and the DRM (Cabeza, Rao, Wagner, Mayer, & Schacter, 2001; Schacter, Buckner, Koutstaal, Dale, & Rosen, 1997), yet no one study to date has compared structural or functional brain differences in participants who complete multiple false

memory tasks in the same study. This biological perspective may shed more light on the patterns of data discovered here.

Furthermore, given the few, small correlations uncovered between personality variables and false memories in this study, researchers who are interested in further exploring the relationships between false memory paradigms may be interested in taking an experimental rather than an individual differences approach. For instance, researchers have studied the effects of divided attention on the production of false memories. In the DRM, dividing participants' attention at encoding has been show to decrease false recognition of critical lures while dividing their attention at retrieval has been shown to increase critical lures (Knott & Dewhurst, 2007). In the misinformation task, participants whose attention is divided at both encoding (Lane, 2006) and retrieval (Zaragoza & Lane, 1998) are more likely to incorporate misleading suggestions into memory. Little is known about how divided attention affects the development of false autobiographical memories, and nothing is known about how it affects different types of false memories within subjects. To the degree that divided attention or any other manipulation affects false memories in the same manner, more can be said about the mechanisms shared by those paradigms.

Conclusion

The research question explored here is simply defined, fundamental to understanding memory, and contributes to a small but growing literature on an understudied question: are there certain people who are prone to developing false memories across multiple contexts? In summary, it seems that the answer is no. The results of this one large study fail to discover any substantial relationships between false memories in three classic experimental paradigms: the misinformation paradigm, the DRM, and imagination inflation. There were small to null relationships between indices of false memory among the three tasks, and while some individual differences predict false memories to a small degree, not one of the personality variables explored in this study predicts false memories in all three contexts.

These data depict the ubiquitous nature of memory distortion. And even though the memories discussed here were produced in the lab, real-world memories may be influenced through the same means. When we attempt to remember and therefore reconstruct our memories, those memories may contain extra bits and pieces from what we have heard, read, or seen from other sources; from what seems to "fit" based on schematic congruence; or even from details generated through our own internal replays and imaginations. Importantly, this research demonstrates that distortions can worm their way into very different kinds of memories for us all, and no one type of person is particularly vulnerable, nor particularly resistant, to incorporating *all* different kinds of those extra bits and pieces into memory.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author, RMN. The data are not publicly available due to their containing information that could compromise the privacy of research participants.

Disclosure statement

No potential conflict of interest was reported by the authors.

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