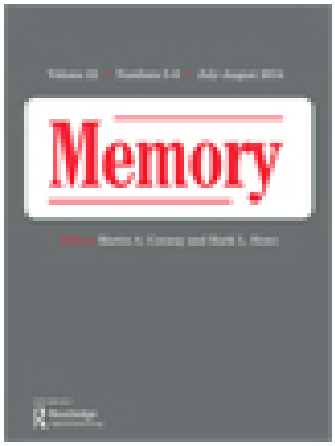

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Factors that influence the generation of autobiographical memory conjunction errors

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Factors that influence the generation of autobiographical memory conjunction errors

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The constructive nature of memory is generally adaptive, allowing us to efficiently store, process and learn from life events, and simulate future scenarios to prepare ourselves for what may come. However, the cost of a flexibly constructive memory system is the occasional conjunction error, whereby the components of an event are authentic, but the combination of those components is false. Using a novel recombination paradigm, it was demonstrated that details from one autobiographical memory (AM) may be incorrectly incorporated into another, forming AM conjunction errors that elude typical reality monitoring checks. The factors that contribute to the creation of these conjunction errors were examined across two experiments. Conjunction errors were more likely to occur when the corresponding details were partially rather than fully recombined, likely due to increased plausibility and ease of simulation of partially recombined scenarios. Brief periods of imagination increased conjunction error rates, in line with the imagination inflation effect. Subjective ratings suggest that this inflation is due to similarity of phenomenological experience between conjunction and authentic memories, consistent with a source monitoring perspective. Moreover, objective scoring of memory content indicates that increased perceptual detail may be particularly important for the formation of AM conjunction errors.

Keywords: Autobiographical memory; False memory; Memory conjunction error; Imagination; Phenomenology.

Autobiographical memory (AM) serves as a personal, richly detailed and usually accurate record of the past. For any one past event we frequently can remember the people involved, the location at which it occurred, our thoughts and emotions as well as the happenings that unfolded. It has long been recognised that such episodic memory representations are stored as constituent features that, upon retrieval, need to be relocated, reactivated and reintegrated (Bartlett, 1932; Schacter, Norman, & Koutstaal, 1998). Having a constructive and flexible episodic memory system is thought to be mostly advantageous (Schacter, Guerin, & St. Jacques, 2011), in that it allows us to recombine details to imagine the future (Schacter & Addis, 2007), creatively solve problems (Howe, Garner, Charlesworth, & Knott, 2011) and update memories with recently acquired information (Lee, 2009; St. Jacques, Olm, & Schacter, 2013). However, there are some downsides to this constructive, flexible set-up, in that it renders us vulnerable to memory distortions and errors. For instance, details from two or more separate memories can occasionally be erroneously integrated, and

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if this is endorsed by the rememberer as a veridical memory, a memory conjunction error is said to have occurred (Reinitz, Lammers, & Cochran, 1992).

Memory conjunction errors have been reported to occur for a range of stimuli, including word syllables (e.g., barter + valley = barley; Kroll, Knight, Metcalfe, Wolf, & Tulving, 1996), compound words (e.g., snowball + sandman = snowman; Jones & Jacoby, 2001), sentences (Reinitz et al., 1992), line drawings of faces (Reinitz, Morrissey, & Demb, 1994) and photographs of faces (Jones & Bartlett, 2009). Exploring memory conjunction errors has helped to illuminate the cognitive mechanisms underlying the episodic memory system, such as feature binding and how these mechanisms are modulated by attentional processes (Jones & Jacoby, 2001; Reinitz, 2001; Reinitz & Hannigan, 2001; Reinitz et al., 1994). Furthermore, memory conjunction errors have been shown to be a highly compelling type of memory distortion, experienced with a sense of recollection (Reinitz, 2001; Reinitz et al., 1992, 1994), which may in part be due to their phenomenological similarity to veridical memories (Johnson, Foley, Suengas, & Raye, 1988; Johnson, Hashtroudi, & Lindsay, 1993). Extending this research on memory conjunction errors into the autobiographical domain should be highly valuable for elucidating cognitive mechanisms of AM construction and authentication. However, AM conjunction errors have thus far received little empirical attention.

To our knowledge, only two studies have explored conjunction errors in AM, and both used a similar technique involving individual diary records. In one study, Odegard and Lampinen (2004) had participants complete a diary over a number of weeks, describing one event that happened every few days and recording major event details, including people, locations, emotions, actions and objects. Following completion of the diary, and unbeknownst to the participant, some of the details in the event descriptions were recombined across events to form a number of conjunction lures. In a subsequent recognition test six weeks later, on average 1.5 conjunction lures were falsely accepted as belonging to the original event[1]. The majority of these conjunction lures were judged as "remembered" as opposed to "known", suggesting they were experienced as phenomenologically real. Burt, Kemp, and Conway (2004) used a similar paradigm, albeit drawing on diaries that had been completed approximately 13 years earlier. Person, place and activity details were recombined between diary entries, with either one, two or three of the details altered, and incorporated into short event descriptions. Participants rated the event descriptions on a 9-point memory scale (with anything above a 4 judged as remembered to some degree), and also estimated the date of the event. It was found that participants at least partially misremembered around six conjunction lures.[2] Location-altered lures were most likely to be falsely remembered, and lures with three details altered were least likely to be given a rating of 1 (i.e., identified as never having happened). Participants reported using landmark events and reconstructive strategies to help date the conjunction events, indicating that complex evaluative processes may be recruited when making source decisions for the recombined events.

Together, these two studies demonstrate that memory conjunction errors in AM can be elicited in the laboratory environment. Moreover, their results suggest that the specific detail altered and the number of memories from which a conjunction event draws from can influence the rates of acceptance of AM conjunction lures. However, the literature on false memories for entirely fabricated events suggests that factors such as plausibility (Mazzoni, 2007; Mazzoni, Loftus, & Kirsch, 2001; Pezdek, Blandon-Gitlin, & Gabbay, 2006; Scoboria, Mazzoni, Kirsch, & Relyea, 2004), imagination (Garry & Polaschek, 2000; Garry & Wade, 2005; Goff & Roediger, 1998; Mazzoni & Memon, 2003; Nash, Wade, & Lindsay, 2009), processing fluency (Garry & Wade, 2005; Sharman, Garry, & Beuke, 2004; Sharman, Manning, & Garry, 2005) and the sensory and emotional detail comprising an event (Heaps & Nash, 2001; Thomas, Bulevich, & Loftus, 2003; Von Glahn, Otani, Migita, Langford, & Hillard, 2012) could also have marked effects on the acceptance of AM conjunction errors.

The two studies reported here further our understanding of the nature of AM conjunction errors by exploring the role that imagination and

[1] In the original paper, it was reported that 15.3% of a total of 190 lures were accepted. Given there were 19 participants, this equates to an average of 1.5 conjunction errors per person.

[2] In the original paper, it was reported that 13.2% of a total of 491 lures were accepted. Given there were 11 participants, this equates to an average of 5.9 conjunction errors per person.

phenomenological qualities play in the formation of this type of memory distortion. We developed a novel approach to explore these questions. By amalgamating the AM conjunction error paradigm (Burt et al., 2004; Odegard & Lampinen, 2004) and the experimental recombination paradigm used previously to study episodic future simulations (Addis, Pan, Vu, Laiser, & Schacter, 2009), we can elicit AM conjunction errors without the need for recording diaries. In Experiment 1 we explored whether imagination (and the vividness and plausibility thereof), degree of recombination and the type of detail altered influence the generation of AM conjunction errors. Experiment 2 builds on the findings of Experiment 1, by elucidating the role of processing fluency and perceptual detail in the imagination inflation effect for AM conjunction errors. The phenomenology of misattribution was also examined, by exploring the differences in memory quality between correctly identified recombined events, AM conjunction errors and authentic AMs.

EXPERIMENT 1

Imagining a fabricated scenario happening increases the likelihood of a false memory forming of that scenario, a phenomenon termed imagination inflation (Garry, Manning, Loftus, & Sherman, 1996; Mazzoni & Memon, 2003; Nash et al., 2009; Thomas & Loftus, 2002). Imagination has been shown to increase the processing fluency (ease of stimulus processing, Garry & Wade, 2005; Jacoby, Kelley, & Dywan, 1989) and phenomenological quality of a mental experience (Heaps & Nash, 2001; Johnson et al., 1993), both of which can be misattributed as an indication of memory authenticity. The imagination inflation effect has been well established for memories of wholly false episodes (for a review see Garry & Polaschek, 2000), however, whether imagination has a similar influence on AM conjunction error rate is currently unexplored. Similarly, while the effect of event plausibility on the formation of memories for wholly false events has been extensively studied (Mazzoni, 2007; Mazzoni et al., 2001; Pezdek et al., 2006; Scoboria et al., 2004), the previous studies on AM conjunction errors have only recombined details in a way that maintained the overall plausibility of each scenario, and so the influence of plausibility on AM conjunction error rate is also unknown. Exploring the influence that imagination and plausibility may have on the formation of AM conjunction errors should illuminate some of the underlying processes by which these errors can propagate.

Consistent with the imagination inflation effect, we hypothesised that following imagination of a hypothetical event involving a set of recombined memory details (i.e., imagined event), the acceptance of the recombined details (i.e., conjunction lure) as belonging to a real episode would increase relative to conjunction lures for which nothing was imagined. In relation to this prediction, we also hypothesised that imagined events rated higher in vividness—serving as an indicator of the perceptual richness of an event (Heaps & Nash, 2001; Hyman, Gilstrap, Decker, & Wilkinson, 1998; Johnson et al., 1993)—and plausibility would be associated with a higher likelihood of subsequently accepting the conjunction lure as real.

Recombined AMs can comprise details originating from two or more separate memories, and as such the number of memories from which a recombined event is constructed may also influence AM conjunction error rate. Our paradigm enabled us to investigate two degrees of recombination: "partial recombinations" of details, where only one detail in an event was altered (e.g., three details originating from two parent memories), and "full recombinations" where many or all details originate from separate memories (e.g., three details originating from three parent memories in our paradigm). Current theories of memory retrieval and reality monitoring provide conflicting predictions on whether partial recombinations or full recombinations of AM details are more likely to result in false memories. A few lines of evidence suggest that partial recombinations are less likely to be identified as real than full recombinations. When presented with conjunctions for words, for instance, individuals may use a recall-to-reject strategy, where recollection of the parent stimuli will allow rejection of the conjunction lure (Jones & Jacoby, 2001, 2005). With respect to AM stimuli, one would expect this recall-to-reject process to be more effective for partial recombinations than full, as the two congruent details from the same event may directly cue retrieval of the original memory, allowing rejection of the erroneous detail. In contrast, full recombinations provide a less specific cue to any one of the constituent memories, thus providing less evidence to suggest that the lure is false. This hypothesis is supported by the finding that fully recombined conjunctions were less likely to be

identified as "never happened" than partial recombinations (Burt et al., 2004).

However, the evidence on the effectiveness of this strategy to reject conjunction lures is mixed (Jones & Bartlett, 2009). Furthermore, Burt et al. (2004) found no difference in the rate at which partial and full recombinations were falsely *remembered*, indicating that with respect to AM, participants did not use the recall-to-reject strategy to prevent false acceptance of a conjunction lure. An alternative hypothesis predicts that partial recombinations are more likely to result in conjunction errors. Theories emphasising the use of plausibility (Mazzoni, 2007; Scoboria, Mazzoni, Jarry, & Shapero, 2012) as a marker for source attribution suggest that when the individual details are randomly recombined, partial recombinations will be more likely to form a plausible combination of details compared to full recombinations (where there is a greater chance that two or more of the details will not be congruent). In this case, we would expect acceptance rates to be higher for partial recombinations compared to full.

For partial recombinations, another influence on acceptance rates may be the type of detail that is switched. When randomly recombined, it is possible that the alteration of a specific type of detail may inherently form more or less plausible scenarios. Previous work in our lab suggests that when imagining a novel future event comprising a person, place and object, the object is the hardest to subsequently remember (McLelland, Devitt, Schacter, & Addis, 2014), suggesting they may be less central to the event in general, and thus more prone to manipulation. Because of this finding, we anticipated that conjunction lures where the object of the memory has been altered would have the highest rate of false acceptance, compared to both location and person-altered lures. Exploring this possibility should reveal whether a specific type of memory detail is more likely to be spontaneously altered during everyday recall.

Method

Participants

Twenty participants (eight male), aged between 19 and 27 years old (M = 20.83, SD = 2.15), were recruited for Experiment 1. All were fluent English speakers with no history of learning disabilities, neurological or psychiatric impairments. This study was approved by the University of Auckland Human Ethics Committee. Participants were compensated with $75 in supermarket vouchers for their time.

Procedure

Session One: Stimuli collection. Participants were asked to recall 150 personal memories from the past 10 years, which typically took between 3 and 4 hours to complete. Each memory had to be of an event specific in place and time, and that lasted for no more than a day. For each memory, participants wrote a brief description and then specified a person (other than themselves) who participated in the event, the location where it occurred, and a salient object that was present. We provided participants with an extensive list of event cues to facilitate retrieval, but memories were not limited to these cues. The experimenter checked the first four events recalled to ensure task instructions had been understood.

Prior to Session Two, the memories were screened for adherence to the specificity instructions; at least 100 valid memories (i.e., those that complied with instructions) were required for recombination. We randomly recombined the memory details to form 162 recombined detail sets (conjunction lures), each consisting of a person, place and object. Of these, 81 were partially recombined sets (with either the person, place or object detail switched; 27 of each type), and 81 fully recombined sets (where the person, place and object were taken from three different memories; see Figure 1). Five recombined detail sets were also created from remaining details to be used as practice trials in Sessions Two and Three.

Session Two: Imagination phase. Session Two took place approximately a week after Session One (M = 7.20 days, SD = 3.32) and was 2 hours in duration. Participants were presented with 108 of the 162 conjunction lures (54 partially and 54 fully recombined) and for each they had 30 seconds to imagine a novel past event involving all three details. Participants were instructed to silently imagine the event in as much detail as possible for the entire time. Participants then rated each imagined scenario for subjective plausibility and vividness on a 4-point scale (1 = low, 4 = high). Finally, at the end of each trial participants typed a one sentence summary of the event they had imagined, to verify that a scenario had indeed been generated (Szpunar & Schacter,

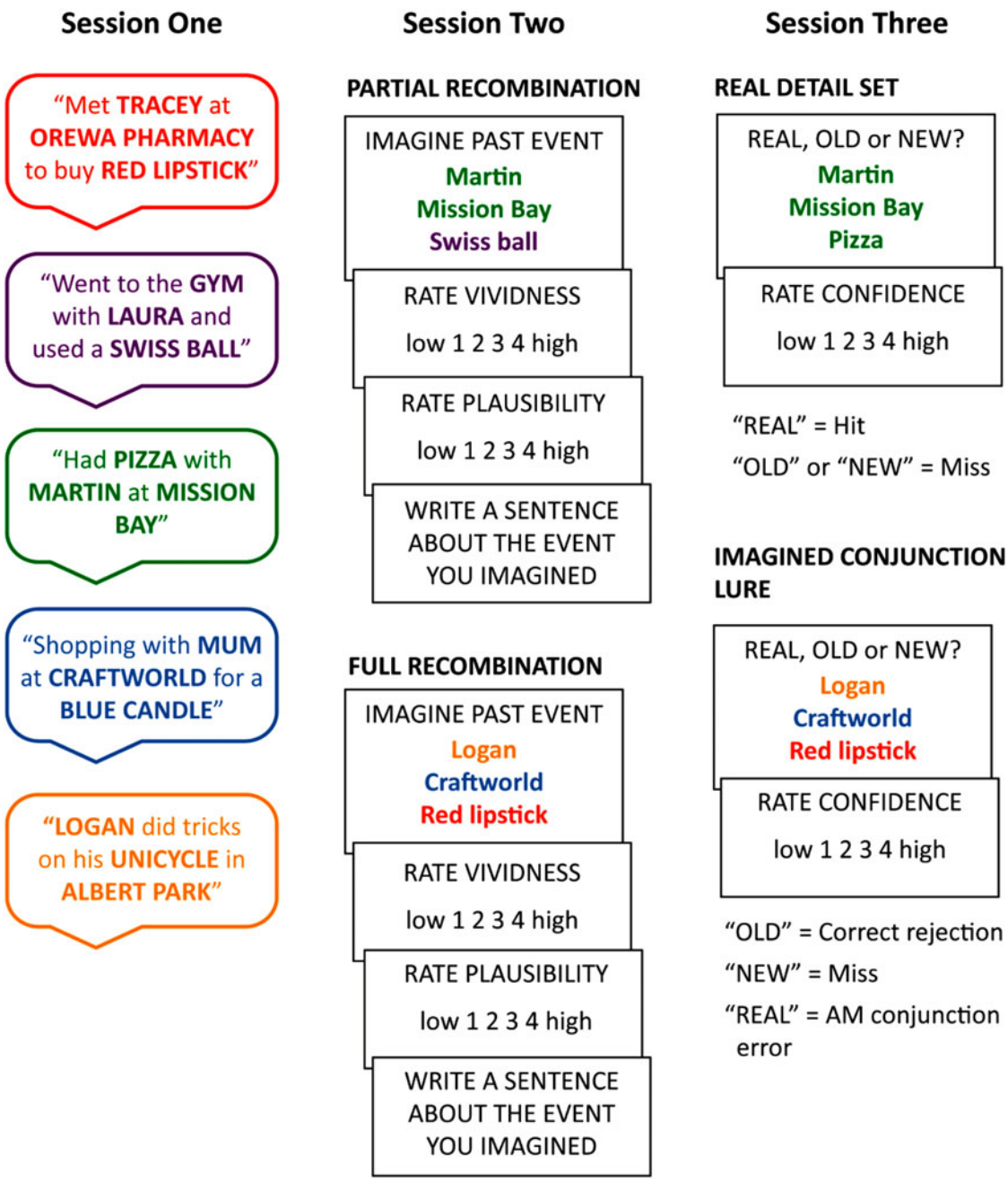

Figure 1. A schematic diagram of example details collected during Session One, recombined details for which events were imagined in Session Two and detail sets presented in the source test during Session Three (including subsequent memory classification according to participant responses). Note colours are used to highlight manipulations; stimuli were presented to participants in black and white. [To view this figure in colour, please visit the online version of this Journal.]

2013). Participants first completed four practice trials to ensure all instructions were understood.

While the detail sets were experimentally recombined in a way so as to avoid reconstructing a combination matching an authentic detail set from Session One, there was the unavoidable possibility that a recombined detail set may correspond to a memory from the individual's past that was not reported in Session One. If a recombination of details prompted a specific memory for a real event involving those particular details, participants were instructed to indicate this by pressing "R" on the keyboard. These sets were excluded from subsequent

analysis, to eliminate the possibility of inadvertently classifying a true memory as a conjunction error. An average of 3.45 sets (M = 3.19%, SD = 3.51) per participant were excluded for this reason.

Session Three: Memory testing. The third and final session was completed approximately a week after the second session (M = 8.56 days, SD = 3.07), and typically took 2 hours to complete. Following 5 practice trials, participants were presented with a total of 216 detail sets, corresponding to authentic memories, imagined events as well as previously unseen conjunction lures (see Table 1 for the number of sets presented in each condition). Each detail set was presented for 5 seconds, during which time participants were asked to make a source judgement, deciding whether they believed the detail set belonged to a real event, an imagined event or was a new recombination they had not seen before. Button press responses were made for this decision, and were followed by a confidence rating on a 4-point scale (1 = low, 4 = high confidence).[3] The critical trials in this source test were those where the participant made a false alarm to a conjunction lure, falsely recognising it as belonging to a real event, indicating an AM conjunction error was made (see Figure 1).

After the source test, participants completed a recall task, writing a short event description for any detail set they had regarded as "real" in the source test (including any conjunction errors made). This procedure helped determine whether conjunction errors had a corresponding mental image and narrative or whether they were simply based on a high level of plausibility or familiarity.

TABLE 1
Number of detail sets presented in Session Three of Experiment 1 in each condition, across degree of recombination

		Recombined	
	Original	*Imagined*	*Previously unseen*
Unaltered	54	–	–
Partial	–	54	27
Full	–	54	27
Total	54	108	54

[3] Participants also completed a size judgement task and an odd/even decision task during this session; because these tasks are not relevant to the current experiment, they will not be included in the following analyses.

Results

Data analysis

Memory conjunction errors were calculated as a percentage of the total number of valid trials per participant. Valid trials excluded those trials in Session Two for which participants indicated the combination of details reminded them of a real memory. Data concerning the percentage of conjunction lures accepted as real (i.e., conjunction errors) were analysed using parametric tests, while ratings of confidence, vividness and plausibility were analysed using appropriate non-parametric tests. Post hoc tests (parametric pairwise comparisons and Wilcoxon signed-rank tests) were considered significant if they exceeded the stated Bonferroni threshold.

Overall acceptance of conjunction lures

An average of 5.45 memory conjunction errors were made per participant (SD = 3.12), 3.45% of the total number of conjunction lures presented in Session Three. Of these conjunction errors, 42.90% (SD = 28.48) were maintained in the recall phase. Conjunction lures for which an event was imagined in Session Two were more likely to result in conjunction errors than lures unseen until the source test, ($t(19)$ = 3.29, p = .004, d = 0.74), consistent with an imagination inflation effect (see Table 2 for percentages). However, imagination in Session Two did not inflate

TABLE 2
Mean percentage of trials resulting in AM conjunction errors, by exposure condition and recombination type for Experiment 1

	Exposure condition		
Type of recombination	*Imagined*	*Unseen*	*Total*
Partial	5.91 (4.05)	3.92 (3.06)	5.23 (3.20)
Person	3.98 (6.11)	1.31 (2.62)	2.86 (3.77)
Place	4.84 (3.77)	1.30 (3.66)	3.44 (2.76)
Object	8.96 (7.78)	6.82 (7.54)	8.02 (6.71)
Full	2.19 (2.18)	0.73 (1.51)	1.70 (1.60)
Total	4.04 (2.45)	2.33 (1.68)	3.45 (1.94)

Standard deviation provided in parentheses.

confidence in real responses for conjunction lures made in Session Three (imagined *Mdn* = 2, unseen *Mdn* = 3, $T = 25.5$, $p = .09$, $r = –0.44$).

We hypothesised that imagined events resulting in conjunction errors would be rated highly in vividness and plausibility in Session Two. As such, we examined whether these ratings differed for imagined conjunction lures that were subsequently correctly identified as imagined (hits), considered new (misses) or incorrectly accepted as real (conjunction errors; see Table 3 for rating averages). A Friedman's analysis of variance (ANOVA) revealed a significant difference between vividness ratings across these subsequent memory conditions ($\chi^2(2) = 13.63$, $p = .001$). Consistent with our hypothesis, follow-up Wilcoxon tests ($\alpha = .017$) indicated that conjunction errors had higher vividness ratings than misses ($T = 24.00$, $p = .01$, $r = –0.61$). There was a trend towards higher vividness ratings for conjunction errors than hits ($T = 48.00$, $p = .06$, $r = –0.43$). Plausibility of imagined events also differed across the subsequent memory conditions ($\chi^2(2) = 18.11$, $p < .001$), with events resulting in conjunction errors rated as more plausible than hits ($T = 12.00$, $p < .001$, $r = –0.77$), and misses ($T = 6.00$, $p < .001$, $r = –0.82$).

Degree of recombination

Another aim of this study was to examine whether the degree of recombination of memory details (partial, full) influenced conjunction error rates. Detail sets which were partially recombined were accepted as real more often than fully recombined sets ($t(19) = 4.87$, $p < .001$, $d = 1.09$; see Table 2), although the degree of recombination did not influence confidence ratings in these decisions (partial *Mdn* = 3.13, full *Mdn* = 3.14, $T = 76.00$, $p = .294$, $r = –0.24$).

The degree of recombination influenced the phenomenology of the imagined events during Session Two (see Table 3). Specifically, vividness ratings were greater for partially recombined sets than for full recombinations ($T = 31.00$, $p = .004$, $r = –0.62$). Similarly, plausibility ratings were also higher for partial recombinations than for full recombinations ($T = 12.00$, $p < .001$, $r = –0.78$). However, the differences in phenomenology of events imagined using partial and full recombinations of details may not be sufficient to explain the erroneous acceptance of conjunction lures during the recognition test. For instance, even when considering only highly plausible and vivid events (i.e., imagined events given ratings of 3 or 4), there was still a trend for partial recombinations ($M = 7.67\%$, $SD = 8.33$) to be accepted more often than full recombinations ($M = 4.25\%$, $SD = 7.55$, $t(19) = 1.79$, $p = .09$, $d = 0.40$).

Type of detail altered

Finally, we explored whether the specific type of detail substituted (person, place, object) in partial recombinations influenced the results. A repeated-measures ANOVA revealed a significant difference in the percentage of conjunction errors made between sets with either the person, place or object detail substituted ($F(1.51, 28.71) = 7.69$, $p = .004$, $\eta_p^2 = 0.29$). Object-altered sets were accepted as real more often than person-altered sets ($p = .012$), and place-altered sets ($p = .04$; see Table 2). No difference was found between person- and place-altered sets ($p = 1.00$). A Friedman's ANOVA indicated that confidence in recognition judgements for conjunction lures did not differ depending on the type of detail altered (person *Mdn* = 3.11, place *Mdn* = 3.10, object *Mdn* = 3.08, $\chi^2(2) = 0.00$, $p = 1.00$).

A Friedman's ANOVA was also run to explore whether the type of detail altered influenced the vividness ratings of imagined events (see Table 3). A significant main effect was found ($\chi^2(2) = 8.84$, $p = .01$). Follow-up Wilcoxon tests revealed that events imagined for object-altered sets were more vivid than events elicited by place-altered sets (*T* =

TABLE 3
Median ratings for phenomenological qualities of events imagined in Session Two of Experiment 1, by subsequent memory condition, degree of recombination and type of detail altered

	Subsequent memory condition			*Degree of recombination*		*Type of detail altered*		
	Hit	*Miss*	*Conjunction error*	*Partial*	*Full*	*Person*	*Place*	*Object*
Vividness[a]	2.78	2.66	3.25	2.80	2.66	2.96	2.52	3.06
Plausibility[a]	2.01	1.17	3.00	2.15	1.76	2.00	1.89	2.62

[a]Rating scale ranges from 1 (low) to 4 (high).

28.00, $p = .003$, $r = –0.64$); comparisons involving person-altered sets were not significant at the Bonferroni-corrected threshold ($\alpha = .017$). A significant difference was found in plausibility ratings between events imagined for person, place and object-altered sets ($\chi^2(2) = 10.30$, $p = .005$). Imagined events elicited by object-altered sets were rated higher in plausibility than events elicited by both person-altered ($T = 32.00$, $p = .005$, $r = –0.61$) and place-altered sets ($T = 14.00$, $p < .001$, $r = –0.76$). No difference was found between the plausibility of events in the place- and person-altered conditions ($T = 65.00$, $p = .14$, $r = –0.33$).

Discussion

We were successful in eliciting AM conjunction errors using a novel recombination paradigm, confirming that time-intensive diary studies are not required to study AM conjunction errors. Specifically, during the recognition test, an average of 5.5 conjunction lures per participant were falsely attributed as belonging to a veridical episode—an average rate higher that the 1.5 conjunction errors reported by Odegard and Lampinen (2004) and on par with Burt et al.'s (2004) rate of 5.9. Furthermore, over a third of these conjunction errors were maintained in the subsequent recall phase, adding to the evidence that AM conjunction errors can be recollected and experienced as phenomenologically real (Burt et al., 2004; Odegard & Lampinen, 2004).

Consistent with the imagination inflation effect, conjunction lures for which an event was imagined resulted in more AM conjunction errors than previously unseen lures. The imagination inflation effect is well established for memories of wholly false episodes (Garry & Polaschek, 2000); our findings suggest that imagination inflation may operate in a similar way for more subtle forms of false memory, such as memory conjunction errors. While we cannot make clear inferences about the mechanism underlying the imagination inflation effect observed in Experiment 1, the finding that over a third of the conjunction errors were later recalled speaks towards a source misattribution driven by an increase in perceptual quality rather than based solely on a feeling of familiarity (Jones & Bartlett, 2009; Jones & Jacoby, 2001; Reinitz, 2001). This hypothesis was further investigated in Experiment 2 by collecting phenomenological ratings not only during imagination in Session Two, but also during retrieval of hits, correct rejections and AM conjunction errors in Session Three.

We hypothesised that the more vivid and plausible an imagined event for a conjunction lure is, the greater the likelihood of being accepted as belonging to a veridical event. The pattern of results is consistent with this notion, with a trend for lures resulting in conjunction errors to be more vivid than those correctly identified as imagined. Moreover, conjunction errors were rated as higher in plausibility in Session Two than imagined lures resulting in hits or misses. This result replicates that of previous studies on plausibility and false memory formation (Mazzoni, 2007; Mazzoni et al., 2001; Pezdek et al., 2006; Scoboria et al., 2004), and is the first demonstration of the influence of plausibility on AM conjunction errors.

Regarding the influence of the degree of recombination on AM conjunction lure acceptance, it has been suggested that partial recombinations may be more likely to be correctly rejected due to the more effective use of a recall-to-reject strategy. However, our results supported the alternative prediction: that the more plausible event constructions associated with partial recombinations increase the likelihood of misattribution as belonging to a veridical memory. In fact, partial recombinations were subsequently accepted as belonging to a real event twice as often as fully recombined detail sets. However, this effect persists even for those events rated high in plausibility and vividness (ratings of 3 or 4), indicating that phenomenology may not wholly account for the increased acceptance of partial recombinations. Processing fluency may also influence acceptance rates of partial recombinations; this possibility is further explored in Experiment 2.

The type of detail that is altered within a conjunction lure was also found to influence false acceptance, with object-altered detail sets accepted more often than person-altered sets. Given that objects may often be less salient within an episode, altering this detail may be less likely to distort the overall integrity of the event, as evidenced by the higher plausibility ratings given to object-altered sets compared to either person- or place-altered sets. However, there is a possibility that the increased acceptance of object-altered sets is due to a presentation order artefact. All detail sets presented during the recognition test, including conjunction lures, were presented in the order

"person/place/object". Due to time pressure, participants may have made a memory decision after considering only the first two details (person and place), without giving the third detail (object) as much weight, despite instructions to consider all three details before responding. Thus, because the person and place details correspond to a veridical event in object-altered sets, participants may be more likely to false alarm without duly considering the object. The data from the plausibility and vividness rating scales speak against this explanation, as well as the finding that object-altered sets comprised over a third of the conjunction errors from the recognition task that were also remembered in the recall phase. However, we nevertheless address this issue in Experiment 2 by presenting the three details in a counterbalanced order.

EXPERIMENT 2

Experiment 2 builds on the results of Experiment 1, by exploring whether processing fluency or enhanced phenomenology during imagination contributes to the imagination inflation effect for AM conjunction errors. This aim was achieved by the inclusion of a control condition to test whether exposure-related processing fluency can elicit an inflation effect similar to that resulting from imagination. We also examined the phenomenological differences between AM conjunction errors, authentic memories and correctly rejected imagined events during the recall phase in Session Three. Furthermore, we controlled for detail presentation order on conjunction lure acceptance by using a counterbalanced recognition test in Experiment 2.

Previous evidence suggests that increasing the phenomenological quality of a fabricated event inflates confidence that the event truly occurred (Mazzoni & Memon, 2003; Thomas et al., 2003). According to the Source Monitoring Framework (Johnson et al., 1993), specific characteristics of a mental experience are used to make an online judgement about the source of that experience at retrieval, based on the tendency for memories from different origins tend to have different characteristics. For example, veridical events are typically rated higher in perceptual, emotional, temporal and spatial detail than both imagined events (Johnson et al., 1988; Justice, Morrison, & Conway, 2013) and false memories for childhood events (Heaps & Nash, 2001). When these phenomenological characteristics overlap—for example when repeated imagining increases the recollective experience of a fabricated event (Heaps & Nash, 2001; Lampinen, Odegard, & Bullington, 2003)—a source monitoring error can occur.

However, the processing fluency of a previously seen conjunction lure may also play an important role in the imagination inflation effect (Garry & Wade, 2005; Sharman et al., 2004, 2005). Memory conjunction errors for words and faces are thought to arise as a result of familiarity with the component parts of the conjunction lure in the absence of recollection of the correct detail combination (Jones & Bartlett, 2009; Jones & Jacoby, 2001, 2005; Marsh, Hicks, & Davis, 2002; Rubin, Petten, Glisky, & Newberg, 1999). Moreover, memory conjunction errors have also been posited to result from over-binding of stimulus components originating from different parental stimuli (Kroll et al., 1996; Reinitz, 2001). Exposure to a conjunction lure via imagination allows associations to form between the initially unrelated details, increasing familiarity with and subsequent ease of retrieval of the conjunction lure, which may be subsequently misattributed as an indicator of authenticity.

Experiment 2 elucidates the relative contributions of fluency and phenomenological quality to the imagination inflation effect for AM conjunction errors. If this effect can be accounted for solely by increased fluency, we would expect to see a similar degree of inflation following both an imagination task and an associative task involving no explicit imagination. If, however, increased phenomenological richness of the mental experience accompanying the conjunction lure also plays a role in the imagination inflation effect, higher AM conjunction error rates should be observed following the imagination task relative to the associative task. In order to assess phenomenological differences between AM conjunction errors, veridical memories and correctly identified imagined events at retrieval, memory quality was measured both subjectively, through self-report ratings, and objectively via independent scoring of an autobiographical interview (AI; Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002). If AM conjunction errors arise due to misattribution of memory-like qualities, as per the source monitoring account, we expect conjunction errors to be more similar to authentic memories than identified imagined events in phenomenal quality.

Method

Participants

Twenty participants (eight male), aged between 18 and 29 years old (M = 20.70, SD = 2.94), participated in Experiment 2. All were fluent English speakers with no history of learning disabilities, neurological or psychiatric impairments, and were compensated with $75 for their time. Note that for the AI, interview data for one participant were lost due to a recording issue.

Procedure

Experiment 2 followed a similar protocol as Experiment 1, with notable differences described below.

Session One: Stimuli collection. Stimuli collection followed an identical procedure to that described in Experiment 1. Prior to Session Two, we randomly recombined the detail sets to make 124 recombined sets, half partially and half fully recombined.

Session Two: Exposure phase. Session Two took place approximately one week after Session One (M = 8.30 days, SD = 3.48) and included both an imagination and a non-imagination associative condition. Participants were presented with 96 conjunction lures; 48 each in the imagination and associative conditions. The presentation order of person, place and object details was counterbalanced across trials. Participants first completed four practise trials to ensure all instructions were understood. Session Two was usually completed within 2 hours.

For the imagination condition, participants imagined an event for 20 seconds. In addition to rating vividness and plausibility of the imagined events on a 5-point scale (1 = low, 5 = high), each conjunction lure was also rated for similarity to previous experiences on a 5-point scale (1 = not at all similar to any previous experiences, 5 = identical to a previous experience), which was followed by a written one sentence summary of the imagined event.

For the associative condition, participants ranked the three details of the conjunction lures in order of subjective pleasantness, from highest to lowest. For example, if shown the details "*Tracey, Pharmacy, Chocolate*" a response might be "I find chocolate more pleasant than Tracey, and Tracey is more pleasant than the pharmacy". As with the imagination condition, participants were instructed to complete this task silently, repeating the judgement for the full 20 seconds. To control for the ratings made in the imagination condition, participants then rated each pleasantness judgement for difficulty on a 5-point scale (1 = very easy, 5 = very difficult), similarity of pleasantness of the three details (1 = very dissimilar, 5 = very similar) and similarity of the conjunction lure to previous experiences, finally writing a sentence indicating the order of pleasantness ranking.

Per participant, an average of 21.25 conjunction lures (M = 22.81%, SD = 8.47) were excluded from analyses because participants indicated the combination of details reminded them of a real memory (a rating of 4 or 5 in previous event similarity). This rating cut-off was determined by averaging the similarity ratings given to a few unaltered sets presented amongst the conjunction lures (M = 4.20).

Session Three: Memory testing. The final session was completed approximately one week after Session Two (M = 9.20 days, SD = 3.62). Participants were presented with 184 detail sets (see Table 4 for the distribution of trials across conditions).

For the source test, each detail set was presented for 5 seconds, during which time participants decided whether they believed the set belonged to a real event ("real"), was a recombined detail set they saw in Session Two ("old") or a new recombination they had not previously seen ("new"). Source judgements were followed by a 5-point confidence rating (1 = low, 5 = high confidence). Participants first completed 9 practise trials to ensure all instructions were understood.

Following the source test, an adapted version of the AI (Levine et al., 2002) was conducted. An

TABLE 4
Number of detail sets presented in Session Three of Experiment 2 in each condition, across degree of recombination

		Recombined		
	Original	*Imagination task*	*Associative task*	*Previously unseen*
Unaltered	60	5	5	–
Partial	–	21	21	15
Full	–	21	21	15
Total	60	47	47	30

average of 10 detail sets were randomly selected based on responses in the recognition test (based on individual performance, the total number of detail sets used ranged from 7 to 16): around four correctly identified real sets, four correctly identified imagined sets and all conjunction lures incorrectly judged real (AM conjunction errors). For each detail set, participants were given 2 minutes to verbally describe what they remember about the associated event in as much detail as possible while being audio-recorded. Following each event described in the interview, participants also rated each event for vividness, level of emotional response and personal significance on a 5-point scale (1 = low, 5 = high), and indicated what perspective the event was viewed from (first person or observer). These event descriptions were later transcribed and scored according to the AI scoring protocol, whereby transcripts were segmented into distinct details which were classified as either internal or external. Internal details were those pertaining directly to the main event, and were further broken down into types: event (details describing the unfolding of the story), emotion/thought (emotional state and thoughts at the time of the event), place (spatial location), time (temporal context) and perceptual (sensory details). External details were details not part of, or specific to, the main event, such as semantic facts or metacognitive statements.

The AI scoring was completed by an independent rater blind to the type of event. To establish inter-rater reliability, this rater and five other raters scored a set of 20 recalled past and imagined future events obtained from a previous study (Addis, Wong, & Schacter, 2008). These scores were subjected to an intraclass correlation analysis, revealing that reliability across raters was acceptable (two-way mixed model; standardised Cronbach's α: internal detail score .97; external detail score .95; event, .89; emotions/thoughts, .89; place, .85; time, .90, perceptual, .97).

Results

Overall acceptance of conjunction lures

Of the 124 conjunction lures presented in Session Three, participants made 2.25 conjunction errors each on average (SD = 2.69), 2.23% of the total number of conjunction lures presented in Session Three. Of the conjunction errors made during the recognition test, 43.06% (SD = 39.86) were still considered to belong to a true memory during the AI.

As with Experiment 1, we explored whether the ratings of vividness and plausibility of events imagined in Session Two differed for imagined conjunction lures subsequently resulting in hits, misses and conjunction errors (medians presented in Table 5). Note that because of the inclusion of the associative exposure condition in Session Two, the number of imagination trials in this analysis is reduced relative to Experiment 1. A Friedman's ANOVA revealed a significant difference between vividness ratings across these subsequent memory conditions ($\chi^2(2) = 10.50$, $p = .004$). Follow-up Wilcoxon tests indicated that there was a trend towards conjunction errors being rated higher than misses ($T = 15$, $p = .06$, $r = –0.54$), while no difference was found between conjunction errors and hits ($T = 34.00$, $p = .733$, $r = –0.11$). Hits, however, were rated as more vivid than misses ($T = 28.00$, $p = .003$, $r = –0.64$). There was also a significant difference in plausibility across the subsequent memory conditions ($\chi^2(2) = 6.17$, $p = .05$). Follow-up Wilcoxon tests indicated that hits were more plausible than misses ($T = 20.00$, $p = .001$, $r = –0.71$). Conjunction errors did not differ in plausibility from hits ($T = 32.00$, $p = .62$, $r = –0.16$) or misses ($T = 17.50$, $p = 0.10$, $r = –0.49$).

Imagination versus associative task

We first examined whether the imagination inflation effect observed in Experiment 1 was replicated. Contrary to Experiment 1, the percentage of

TABLE 5
Median ratings for phenomenological qualities of events imagined in Session Two of Experiment 2

	Subsequent memory condition			*Degree of recombination*		*Type of detail altered*		
	Hit	*Miss*	*Conjunction error*	*Partial*	*Full*	*Person*	*Place*	*Object*
Vividness[a]	3.60	2.78	3.75	3.20	3.00	3.46	3.14	3.36
Plausibility[a]	2.66	2.08	3.00	2.41	1.83	2.29	2.00	2.77

[a]Rating scale ranges from 1 (low) to 5 (high).

conjunction errors occurring in response to unseen lures did not significantly differ from the percentage of imagined conjunction errors ($t(19) = .47$, $p = .65$, $d = 0.10$; see Table 6). This unexpected pattern of results is likely attributable to the more stringent exclusion criteria for recombined events. In other words, while conjunction lures presented in Session Two that reminded participants of a real memory were excluded from analysis, it was not possible to do the same for previously unseen lures. Thus the percentage of unseen lures resulting in conjunction errors likely includes recombinations corresponding to real events unreported in Session One. As a result, the true rates of memory conjunction error acceptance for previously unseen lures may be more conservative than that reported. Indeed, when comparing the uncorrected rate of conjunction errors (those in the imagined condition without trials considered similar to real memories removed), there is a trend for more conjunction errors to occur in the imagined condition ($M = 5.17\%$, $SD = 5.41$) compared with the unseen condition ($M = 3.11\%$, $SD = 5.16$, $t(19) = 1.99$, $p = .06$, $d = 0.44$).

However, the main aim of this study was to compare the influence of an imagination and an associative task on conjunction lure acceptance rates to determine whether increasing fluency results in a similar inflation of conjunction lure acceptance as imagination. For the associative condition, 35% of participants made at least one conjunction error, whereas in the imagination condition, 60% of participants made at least one conjunction error. When examined as a percentage of total trials for each condition, more conjunction errors were made in the imagination condition than the associative condition ($t(19) = 2.62$, $p = .017$, $d = 0.59$; see Table 6). A Wilcoxon signed-rank test demonstrated that participants were more confident in responses for imagined detail sets ($Mdn = 4.03$) compared to associative detail sets ($Mdn = 3.46$, $T = 29.00$, $p = .003$, $r = -0.63$). Participants were also more accurate in determining source for imagined detail sets ($M = 68.50\%$ correct, $SD = 19.73$) than associative detail sets ($M = 29.51\%$ correct, $SD = 14.5$, $t(19) = 9.33$, $p < .001$, $d = 2.09$).

Phenomenological characteristics during retrieval of real memories, correctly rejected imagined events and conjunction errors

Objective scoring of event phenomenology. Average AI scores for each event type (real, correctly identified imagined and conjunction error) were analysed using a 3 × 2 repeated measures ANOVA, to explore differences across event type and type of AI detail (internal, external). A significant main effect of event type was found ($F(1.33, 13.32) = 4.76$, $p = .039$, $\eta_p^2 = 0.32$); post hoc pairwise comparisons revealed that real events had more detail on average than imagined events ($p = .008$; see Table 7). There was also a significant main effect of AI detail type ($F(1, 10) = 5.51$, $p = .041$, $\eta_p^2 = 0.35$), with more internal than external detail generated overall.

Importantly, a significant interaction was found between event type and detail ($F(2, 20) = 8.57$, $p = .004$, $\eta_p^2 = 0.46$). Post hoc pairwise comparisons revealed that real events had more internal detail than both imagined ($p = .002$) and conjunction errors ($p = .030$). No differences were found across the event types for external detail. We further broke down internal details into subcategories (event, thought, place, time, perceptual) to explore whether one particular type of detail was driving this effect. A 3 × 5 ANOVA revealed a significant interaction between event type and type of internal detail ($F(2.33, 23.31) =$

TABLE 6
Mean percentage of trials resulting in AM conjunction errors, by exposure condition and recombination type for Experiment 2

	Exposure condition			
Type of recombination	*Imagination*	*Associative*	*Unseen*	*Total*
Full	1.56 (3.44)	1.24 (2.20)	0.67 (2.05)	1.20 (2.13)
Partial	4.17 (4.00)	1.53 (3.39)	4.75 (6.47)	3.47 (3.45)
Person	2.25 (6.97)	0 (0)	4.00 (8.21)	2.22 (3.81)
Place	5.05 (9.63)	1.43 (4.40)	4.00 (8.21)	3.59 (4.87)
Object	4.33 (9.04)	2.92 (7.29)	6.00 (11.42)	4.29 (6.25)
Total	2.70 (2.77)	1.38 (2.32)	3.11 (5.16)	2.30 (2.83)

Standard deviations are provided in parentheses.

TABLE 7
Mean AI scores, and median ratings for phenomenological qualities of events remembered in Session Three of Experiment 2

	Hit (real)	*Correct rejection (imagined)*	*Conjunction error*
External	7.48 (4.90)	9.36 (7.32)	12.39 (12.43)
Internal	23.18 (10.48)	13.03 (5.40)	13.32 (5.47)
Event	13.65 (6.84)	8.01 (4.43)	7.17 (2.82)
Thought	2.84 (2.34)	0.45 (0.51)	0.7 (1.61)
Place	2.47 (0.97)	2.25 (0.74)	2.5 (1.20)
Time	1.46 (1.29)	0.74 (0.76)	0.56 (0.79)
Perceptual	2.77 (1.59)	1.58 (1.35)	2.29 (2.48)
Vividness[a]	3.82	2.67	3.26
Emotion[a]	2.67	1.58	2.11
Personal significance[a]	2.50	1.29	1.13

Standard deviations are provided in parentheses.
[a]Rating scale ranges from 1 (low) to 5 (high).

8.25, p = .001, η_p^2= 0.45). Post hoc pairwise comparisons revealed that real events had more event and thought detail than both imagined (p = .007, p = .01) and conjunction errors (p = .015, p = .009). Interestingly, conjunction errors had a similar amount of perceptual detail as real events (p = 1.00), while events correctly identified as imagined had less perceptual content than real events (p = .038). No differences were found for place or time details.

Subjective ratings of event phenomenology. During the AI, ratings of vividness, emotion and personal significance were collected for real memories, correctly rejected imagined events and conjunction errors (see Table 7). A Friedman's ANOVA found a significant difference in vividness ratings between real memories, imagined events and conjunction errors ($\chi^2(2)$ = 12.40, p = .001). Follow-up Wilcoxon tests revealed that real memories were rated higher in vividness (Mdn = 3.82) than imagined events (T = 5.00, p < .001, r = –0.78). Conjunction errors were rated intermediary in vividness, and did not differ significantly from either real (T = 7.00, p = .035, r = –0.60) or imagined events (T = 18.00, p = .198, r = –0.39). A similar pattern of results was observed for ratings of emotion ($\chi^2(2)$ = 13.74, p < .001), with real events rated significantly more emotional than imagined events (T = 21.00, p = .001, r = –0.70). Though trending, no significant differences were found between emotion ratings for conjunction errors and real (T = 10.50, p = .023, r = –0.65), or imagined events (T = 13.50, p = .166, r = –0.42) at the Bonferroni-corrected threshold. Regarding ratings of personal significance, a main effect was found ($\chi^2(2)$ = 16.44, p < .001), with real events considered more significant than imagined events (T = 0.00, p < .001, r = –0.81) and conjunction errors (T = 0.00, p = .002, r = –0.81).

A significant main effect was also found for the perspective the event was viewed from ($F(2, 22)$ = 6.64, p = .006, η_p^2 = 0.38). Real events were more often viewed from a first person perspective (proportion = .87, SD = 0.21) than imagined events (proportion = .62, SD = 0.32, p = .035). The rate of first person conjunction errors (proportion = .85, SD = 0.31) did not differ from the rate for real events (p = 1.00). Similar to the difference between real and imagined events, there was also a trend towards conjunction errors being viewed from a first person perspective more often than imagined (p = .08).

Degree of recombination and type of detail altered

Replicating the results from Experiment 1, detail sets which were partially recombined were accepted as real more often than fully recombined sets ($t(19)$ = 4.68, p < .001, d = 1.05, see Table 6 for percentages). A Wilcoxon signed-rank test revealed no difference in confidence ratings between partially (Mdn = 3.62) and fully recombined sets (Mdn = 3.69, T = 57, p = .08, r = –0.40). Degree of recombination influenced the vividness and plausibility of the imagined events during Session Two. Wilcoxon signed-rank tests revealed that imagined partial recombinations were rated as more vivid (T = 44.00, p = .021, r = –0.51) and more plausible than full recombinations (T = 8, p < .001, r = –0.75; see Table 5).

We examined whether the type of detail altered (person, place, object) influenced

conjunction lure acceptance even after counterbalancing the order of detail presentation. When examined as a percentage of conjunction lures accepted of the total lure trials for each type of detail altered, no significant differences were found ($F(2, 38) = 1.11$, $p = .34$, $\eta_p^2 = 0.06$). A Friedman's ANOVA was run to explore differences in vividness and plausibility ratings for imagined events according to the type of detail altered (see Table 5). No significant difference in vividness was found ($\chi^2(2) = 2.84$, $p = .26$). A significant main effect for plausibility was found ($\chi^2(2) = 9.95$, $p = .005$); place-altered sets were rated as less plausible than both object- ($T = 13.50$, $p = .001$, $r = –0.67$) and person-altered sets ($T = 41.50$, $p = .016$, $r = –0.53$).

Discussion

In Experiment 2 an average of 2.25 conjunction lures per participant were falsely accepted as belonging to a real event. While the overall acceptance of conjunction lures is lower than that observed in Experiment 1, this is likely due to lower acceptance of conjunction lures in the associative condition. Indeed, the percentage of accepted *imagined* events is comparable between the two studies (4% vs. 3%), as well as the percentage of conjunction errors maintained in the subsequent recall test (43% for both).

As in Experiment 1, imagined events resulting in conjunction errors were rated as more vivid and plausible in Session Two than those subsequently identified as imagined or previously unseen. However, surprisingly these differences did not reach significance, potentially due to a lack of power owing to fewer imagined trials (in which vividness and plausibility ratings were obtained) than Experiment 1.

While the imagination inflation effect from Experiment 1 was not replicated in Experiment 2, this pattern of results is likely due to the more stringent exclusion criteria used in Experiment 2. Any events rated 4 or 5 on a scale of similarity to previous events were excluded, potentially excluding lures that were similar—but not identical—to previous events, and thus reducing the conjunction error rate in the imagination condition. Moreover, because it was not possible to obtain these ratings for the previously unseen lures, some of the unseen lures considered real may in fact have corresponded to previously experienced events. Therefore, the true conjunction error rate for unseen lures is likely to be more conservative than that reported. Indeed, when comparing the uncorrected rate of conjunction errors for imagined detail sets to unseen sets, the imagination inflation effect approached significance.

Consistent with our hypotheses, conjunction lures for which an event had been imagined were accepted more often than conjunction lures for which an association had been made between details but no explicit event imagined, even despite higher overall accuracy in source decisions in the imagination condition. This result suggests that something other than increased fluency inflates conjunction error rates for imagined events. A likely candidate, consistent with the source monitoring account of false memories, is increased phenomenological quality afforded by the imagination task (Johnson et al., 1993). The subjective ratings collected in Session Three further support the perspective that AM conjunction errors occur as a result of misattribution of memory-like qualities, as conjunction errors were rated as intermediary between correctly identified imagined and real events for vividness and emotionality, and were more often viewed from a first person perspective, similar to real memories. For personal significance, however, real events were rated significantly higher than both correct rejections of imagined events and conjunction errors. In order to determine the significance of an event in one's life, associated memories are likely to be retrieved for evidence of any lasting consequences of the target event. Because both AM conjunction error and rejected imagined events did not truly take place, they will have fewer associations with existing memories (Johnson et al., 1988), and therefore less available evidence to suggest these events have had a significant impact on one's life.

We were also interested in whether the independently scored AI results conferred with the subjective ratings; however, the AI results were mixed. Contrary to our hypotheses, descriptions of real events contained more internal details overall than both imagined and conjunction error events, and this effect appeared to be mainly driven by differences in event and thought details. Phenomenological distinctions have previously been found between true and false memories, which were largely accounted for by differences in rehearsal frequency (Heaps & Nash, 2001). Indeed, repeated imagination has been shown to increase the recollective qualities of false

memories (Hyman et al., 1998). The short imagination time and intersession interval in the current study may have limited the phenomenological similarities between authentic and conjunction error events. Place and time details did not differ across the memory conditions. This is unsurprising, as regardless of recombination, all detail sets included a place in which to locate the event, and the combination of person and place details typically allowed distinction of a period in which the event could have occurred. Interestingly, the pattern of perceptual detail mirrored the subjective vividness ratings, with real events having more perceptual detail than imagined, and conjunction errors intermediary. This pattern is consistent with previous research on the effect of sensory information on false memory formation (Thomas et al., 2003), and suggests that perceptual detail may play a particularly important role in source misattribution.

However, processing fluency plays at least some role in the generation of AM conjunction errors, as demonstrated by acceptance of conjunction lures in the associative condition. The associative task may have facilitated the binding of details within a conjunction lure, increasing the fluency of that lure, which may then have been misattributed as an indicator of veracity. Although the associative task was designed to facilitate detail association without generation of a mental image, we cannot rule out the possibility that spontaneous construction of an event and corresponding mental image may have occurred during the associative task, leading to the moderate increase in conjunction lure acceptance due to an increase in phenomenological quality (Thomas et al., 2003). Unfortunately, the numbers of conjunction errors were too low when split into imagined and associative conditions to statistically test whether conjunction errors were rated higher in phenomenological characteristics at retrieval following the imagination versus the associative condition.

The effect of recombination degree in Experiment 1 was replicated, with partial recombinations being accepted at a higher rate, as well as being rated more vivid and plausible than full recombinations. We further hypothesised that due to both the peripheral nature of object details within an episode, this detail type would be more interchangeable between events (Dijkstra & Misirlisoy, 2009). While object- as well as place-altered sets were accepted more than person-altered sets, this difference did not reach significance, suggesting that when presentation order is counterbalanced, one type of detail is not inherently more interchangeable within events than another. In line with this, no difference in vividness was found according to type of detail altered. Place-altered sets were rated as less plausible than both object- and person-altered sets, reflecting the results observed in Experiment 1. Many of the locations spanned continents as well as time periods (e.g., high school versus university), and so randomly switching this detail could have resulted in an event taking place on the other side of the world, or at a completely different period in one's life, than it had originally, resulting in more implausible recombinations than when altering either person or object.

GENERAL DISCUSSION

Across two experiments, we have demonstrated that features from one AM may be incorrectly incorporated into another, forming AM conjunction errors that surpass typical reality monitoring checks. Moreover, the factors influencing the formation of conjunction errors were explored. Our results indicate that imagination increases the likelihood of conjunction errors for relatively recent AMs, extending previous reports of the imagination inflation effect for false memories of simple actions (Thomas et al., 2003) and childhood events (Mazzoni & Memon, 2003). Furthermore, our results suggest that the imagination inflation effect is likely driven by source confusion due to an increase in phenomenological characteristics of the mental simulation for the conjunction event.

The results of Experiment 1 revealed that conjunction lures for which an event was imagined were accepted more often than previously unseen events. Experiment 2 further compared false acceptance rates between an imagination and an associative task in order to delineate the role of fluency in this inflation effect. The imagination task resulted in higher acceptance of AM conjunction errors than did the associative task, indicating that something more than processing fluency accounts for the imagination inflation effect for AM conjunction errors.

According to the source monitoring account of false memories, one possible mechanism underlying the imagination inflation effect is that imagination enhances the phenomenological richness of a simulated event and its similarity to authentic

memories, thus increasing the likelihood of source confusion taking place (Johnson et al., 1993). A number of our findings across both experiments are consistent with this idea. First, generating a more vivid simulation during the imagination session increased the likelihood of a later conjunction error during the memory testing session. Second, at retrieval, conjunction error events were rated as intermediate between real and imagined events in terms of subjective vividness, emotionality and use of a field perspective. Moreover, the objective scoring of memory content indicated that it is not just an overall increase in episodic detail, but specifically perceptual detail, that may be most important for the occurrence of AM conjunction errors. While previous studies have demonstrated the importance of sensory detail for false memory formation (Gonsalves et al., 2004; Johnson et al., 1993; Thomas et al., 2003; Von Glahn et al., 2012), the relationship between perceptual detail and false memory construction is not clear cut, as some studies report no relationship between quality ratings of an imagined event and false memory formation (Garry, Frame, & Loftus, 1999), nor between general mental imagery ability and susceptibility to false memories (Heaps & Nash, 1999). Future research may focus on delineating the conditions under which increasing perceptual detail may contribute to the construction of false memories.

Plausibility also appeared to play some role in the formation of AM conjunction errors, consistent with previous empirical research demonstrating the influence of plausibility on false memory acceptance (Mazzoni, 2007; Mazzoni et al., 2001; Pezdek et al., 2006; Scoboria et al., 2004). We found that conjunction errors tended to be associated with more plausible imaginings than correctly rejected conjunction lures, though this did not reach significance in Experiment 2. Moreover, in both experiments partially recombined conjunction lures—which facilitated the imagination of more plausible events—were more likely to result in conjunction errors than fully recombined conjunction lures. Interestingly, this effect persisted even at high levels of plausibility and vividness, suggesting that other factors, such as fluency, may also contribute to the increased acceptance of partial recombinations. That is, the relative ease of constructing a scenario for partial recombinations likely increases the ease with which the event is later retrieved, and this fluency may be misattributed as an indicator of event veracity. While Experiment 2 showed that overall, imagination influenced conjunction error rates over and above fluency, the fluency hypothesis is indirectly supported by the higher vividness of partial recombination events, suggesting they were imagined with greater ease than full recombinations. It is important to note that the fluency and phenomenological quality explanations of false memory formation are not necessarily mutually exclusive. In addition to enhancing recollective detail, imagination also likely facilitates the binding of disparate memory details, increasing the fluency of later retrieval. Thus, imagination may enhance both the detail and fluency of memories, both of which can be misattributed as indicators of event authenticity.

Burt et al. (2004) also explored the influence of degree of recombination on conjunction lure acceptance, and in contrast to the current study, observed that full and partial recombinations were equivalent in the rate at which they were judged as "somewhat remembered" or higher. A number of methodological differences between Burt et al.'s study and the current one could account for this difference in results. Notably, only recombinations considered plausible were utilised by Burt et al. (whereas plausibility was allowed to vary using random recombinations in the current study), thereby reducing the phenomenological difference between partial and full recombinations. Furthermore, the current study used a short response time limit, which may have encouraged source decisions based on fluency (Jones & Jacoby, 2005), while Burt et al. imposed no response time limitations. These differences, in addition to the longer delay between event occurrence and source test (13 years on average) may have meant that participants in their study used alternative strategies to identify conjunction lures (see also, Odegard & Lampinen, 2004). This disparity in the influence that recombination degree can have on conjunction error formation opens some interesting avenues for further research into the cognitive processes used when making source decisions.

We hypothesised that the type of detail altered may influence AM conjunction error formation. Place- and object-altered sets appeared to be accepted more often than person-altered sets, however, this did not reach significance in Experiment 2 once the presentation order was counterbalanced. Depending on the specifics of the event, one type of detail may not be inherently more interchangeable than another, for instance if such a change impacts on event plausibility. It is likely

that different features are particularly salient depending on the nature of the memory; for example, when remembering lunch with a friend, the person or place may be the most salient detail, but when recalling a shopping trip, the object purchased could be considered the most important feature of the event. While we focused on person, place and object details due to their likely consistency across the timeframe of a single event, AMs are composed of many other types of features that may be altered, including (but by no means limited to) emotions (Odegard & Lampinen, 2004), activity (Burt et al., 2004), smell and internal thoughts. Future research may benefit from exploring the likelihood of conjunction errors forming when other types of memory features are altered.

These results may have implications for situations in which memory authenticity is of high importance, such as in eye witness testimony (Loftus, 2003). It has previously been demonstrated that eyewitnesses can "remember" with high confidence one actor performing actions actually performed by another, which could lead to incorrect identification of an innocent bystander as the perpetrator of a crime (Kersten, Earles, & Upshaw, 2013).When recalling a crime scene, a witness may erroneously incorporate or substitute event details for those of other memories. Imagining such a conjunction event (such as what may happen during interrogation or therapy, Kassin & Gudjonsson, 2004; Leding, 2012; Poole, Lindsay, Memon, & Bull, 1995) could further increase the likelihood of false belief in the memory distortion, especially if the substitution is plausible (e.g., swapping a knife for a gun). As many crime cases rely on eyewitness testimony due to a lack of forensic evidence (Zember, Brainerd, Reyna, & Kopko, 2012), it is imperative to an effective justice system to understand the conditions under which memory can become distorted.

In summary, we have replicated the occurrence of conjunction errors in AM, inducing these errors in the laboratory without the need for time-intensive diary studies. Moreover, the current study serves to highlight the complexity of false AMs, demonstrating that multiple factors underlie false AM construction, including the phenomenological characteristics of the fabricated event, the ease with which the event can be constructed and retrieved, as well as the plausibility of the recombination.

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