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Are eyewitness accounts biased? Evaluating false memories for crimes involving in-group or out-group conflict

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ABSTRACT

Eyewitness testimony has been shown to be unreliable and susceptible to false memories. Whether eyewitness memory errors are influenced by the victim's group membership (relative to both the eyewitness and perpetrator) is underexplored. The current study used complementary behavioral and neuroimaging approaches to test the hypothesis that intragroup conflict heightens participants' susceptibility to subsequent false memories. Healthy young adults witnessed and later answered questions about events in which the perpetrator and victim were either 1) identified as in-group members relative to each other and the eyewitness, 2) out-group members relative to the eyewitness, but not each other, or 3) out-group members relative to each other (Experiments 1a and 1b). When perpetrators and victims were in-group members (intragroup conflict), participants showed heightened false memory rates. Moreover, false memories increased upon crime realization. Neuroimaging data analysis revealed that salient (as compared to ambiguous) intragroup conflict elicited heightened activation in neural regions associated with resolving cognitive conflict (anterior cingulate cortex; ACC). Increased functional connectivity between the ACC and dorsomedial prefrontal cortex was associated with subsequent false memories (Experiment 2). Results suggest that the social salience of the intragroup conflict may have been associated with participants' increased susceptibility to false memories.

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Although juries generally weigh eyewitness testimony heavily in their deliberations (Abshire & Bornstein, 2003; Lindsay, Lim, Marando, & Cully, 1986), eyewitness accounts are often unreliable and easily susceptible to false memories (Loftus, 1975, 1979, 2005; Loftus, Miller, & Burns, 1978; Mitchell & Zaragoza, 2001; Okado & Stark, 2005; Zaragoza, Belli, & Payment, 2006; Zaragoza & Lane, 1994). Much research on false memories in eyewitness testimony has focused on memory errors regarding the identity of the perpetrator of the crime (e.g., Morgan III, Southwick, Steffian, Hazlett & Loftus, 2013), including how the perpetrator's group membership (relative to the eyewitness) may influence memory errors (e.g., Howard & Rothbart, 1980). However, a small body of research suggests that eyewitnesses' false memories may also extend to the details of the crime itself (e.g., Loftus, 2005; Okado & Stark, 2005). Two critical and overlooked considerations in this work regard: 1) whether these factors interact, and 2) how a victim's group membership (relative to both the eyewitness and perpetrator) impacts eyewitnesses' susceptibility to false

memories (but see Nourkova, Bernstein, & Loftus, 2004). The current studies examined these questions.

Prior work demonstrated the importance of tying event details to their context or source to support true memories, particularly for social information (Howard & Rothbart, 1980). According to this work, false memories for crime-related details arise from mistakenly combining elements of past experiences (i.e., source misattributions; Okado & Stark, 2005; Stark, Okado, & Loftus, 2010). In an experimental context, these source misattributions may emerge when participants retrieve incorrect information about the event they witnessed, and attribute their memory for that information to the original event. Indeed, memory errors can result from mistakenly combining details of distinct episodic or autobiographical memories (e.g., Burt, Kemp, & Conway, 2004; Carpenter & Schacter, *in press*; Devitt, Monk-Fromont, Schacter, & Addis, 2016; Odegard & Lampinen, 2004). Eyewitnesses were particularly prone to these types of source monitoring errors following a time delay, during which memory for event-related details

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deemed to be behaviorally irrelevant may weaken or fade (Hardt, Nader, & Nadel, 2013). During this delay, exposure to alternate sources of information related to details of the witnessed event (e.g., accounts of other witnesses, news reports, and even the questions asked by the investigator) may incorrectly modify witnesses' memory traces. Given weak original traces, individuals may not detect discrepancies between reactivated event details and post-event misinformation contradicting original event details. As a result, witnesses may misattribute the source of the more recently presented misinformation to the original event, creating false memories (e.g., Hupbach, Gomez, & Nadel, 2009; see Mitchell & Johnson, 2009; for a review).

The extent to which the eyewitnesses attend to the salient elements of the event (e.g., the victim and/or perpetrator of a crime), at the expense of attending to other, less salient elements of an event (e.g., the item that was stolen), may influence the strength of original memory traces. For instance, the weapon-focus effect (Loftus, 1979) demonstrates that people remember central emotional elements of events (e.g., the weapon) at the expense of other details (e.g., peripheral elements within the scene). We therefore extended eyewitness false memory research to the domain of group membership, which we anticipated would have high social salience for the eyewitnesses. We anticipated that victim and/or perpetrator group membership (relative to the eyewitness and/or each other) would affect eyewitnesses' source misattributions for event-related details by drawing their attention away from less salient crime-related details and toward the more salient conflict between the victim and perpetrator. There are several ways in which this could occur.

For instance, source misattributions could be lower for crimes involving victims who are in-group members relative to the witness (irrespective of the perpetrator's group membership) because the eyewitnesses may view an in-group victim as being more similar to themselves than an out-group victim. If this is the case, then eyewitnesses may form stronger memory traces for details of the original event. Relating information to the self yields memory enhancements because self-reference promotes greater elaboration and organization of information during encoding (see Symons & Johnson, 1997 for a meta-analysis). Supporting this prediction, individuals affiliate less with in-group members violating social norms (e.g., committing a crime), but more when they are victims of social norm violations (Eidelman & Biernat, 2003; Marcus-Newhall, Blake, & Baumann, 2002; Marques & Yzerbyt, 1988; Nourkova et al., 2004; Pinto, Marques, Levine, & Abrams, 2010). Thus, stronger affiliation with the in-group victim may boost memory performance because the in-group victim would be seen as being similar to the self.

If both the victim and the perpetrator are in-group members (relative to each other and the witness), two divergent possibilities emerge. First, fewer source misattributions may occur when eyewitnesses view an event depicting two in-group members relative to the in-group victim condition described above because these crimes may have the most salience to eyewitnesses by involving two in-group members versus one. Second, eyewitnesses may not attend as much to crime-related details with both in-group perpetrators and victims because the intragroup conflict may violate behavioral expectations of in-group members. Indeed, people have worse memory for negative in-group versus out-group member behaviors, suggesting preferential memory for expectation-consistent behaviors (Howard & Rothbart, 1980). Here, intragroup conflict could result in more false memories than conflict between two out-group members relative to the witness, ambiguous conflict (e.g., an in-group member victim relative to the witness, but a perpetrator from an unidentified group), or intergroup conflict (e.g., in-group member victim relative to the witness, but out-group member perpetrator relative to both).

To resolve these disparate possibilities, we assessed eyewitnesses' false memory for crimes involving either in-group victims and in-group perpetrators or out-group victims and out-group perpetrators (Experiment 1a). We then expanded these findings in Experiment 1b by examining false memory rates for intergroup conflict (in-group victim, out-group perpetrator). To better characterize our predicted results, we used functional magnetic resonance imaging (fMRI) to identify the neural mechanisms underlying source misattributions for crime-related details impacted by victim and/or perpetrator group membership (Experiment 2).

Across all experiments, we used university affiliation (in-group: Indiana University, out-group: Purdue University) to manipulate group membership (e.g., see Bernstein, Young, & Hugenberg, 2007; Wilder, 1990).

Experiment 1a

Here, we examined whether the victim and/or perpetrator group membership relative to the witness affected witnesses' false memories for crime-related details. We predicted that false memories would differ for crimes depicting an in-group victim and an in-group perpetrator. However, we tested two competing hypotheses regarding the directionality of this effect. If self-relevance improves memory for crime-related details, we predicted fewer false memories in a crime involving any in-group member (victim and/or perpetrator) as compared with the out-group condition. If intragroup conflict (shared in-group membership between victim, perpetrator, and eyewitness) directs attention

toward resolving behavioral conflict between the in-group members, we anticipated more false memories given intragroup conflict only. To disentangle the effect of a crime featuring an in-group victim from a crime featuring an in-group victim and in-group perpetrator, we presented participants with crimes in which the conflict was either ambiguous (e.g., the victim was explicitly identified as being an in-group or out-group member, but the perpetrator's group membership was not explicitly identified), or salient (e.g., the victim and the perpetrator were both explicitly identified as being in-group or out-group members).

Materials and methods

Participants

A priori power analyses conducted using G*Power (Faul, Erdfelder, Buchner, & Lang, 2009) indicated at least 26 participants would be necessary per condition to detect within-subject effects using a medium effect size ($\eta_p^2 = .10$), alpha = .05, and power = .95. Because participants were required to complete two sessions and needed to achieve above chance performance on the memory test to be included, a total of 53 undergraduates ($M_{age} = 22$ years, $SD = 2.96$, 38 female, all White) from Indiana University with normal or corrected-to-normal vision and hearing, who were not taking antidepressants, and who were native English speakers, were recruited. Participants either

received course credit or monetary compensation. The Indiana University IRB approved this research.

Encoding the original events

Participants viewed a modified version of slideshows used by Okado and Stark (2005) that depicted (in counterbalanced order) eight unique everyday life events. Six events depicted criminal activities (e.g., a wallet being stolen), and two depicted neutral activities (e.g., a woman going to the grocery store). Each slideshow contained 50 images, presented for 3500 ms each with a 500 ms inter-picture interval (e.g., black screen). Participants were told that they would rate the slideshows on a variety of measures in a second session (approximately 24-hrs later), so it was important that they were attending to the images presented, but were unaware that they would have a future memory test.

In the six events depicting criminal activity, there was a clearly identifiable perpetrator and a victim. To manipulate perceived group membership of the perpetrator and/or the victim, we used Adobe Photoshop Elements 11 Version 11.0 to superimpose symbols (e.g., logos, banners, or building names) explicitly associated with either Indiana University (in-group) or Purdue University (out-group) onto each of the 50 images for each of the eight slideshows (see example in Figure 1). We chose Purdue University as the out-group because Indiana University (where the study was conducted) and Purdue University are both public universities in Indiana, and there is a well-known rivalry between the



Figure 1. An example image from one slideshow depicting how images were manipulated to identify the victim and the perpetrator (i.e., salient conflict condition) or only the victim (i.e., ambiguous conflict condition) as an in-group (i.e., Indiana University) or an out-group (i.e., Purdue University) member. In each condition, the same items were manipulated (e.g., perpetrator's jacket, victim's wallet, victim's mouse pad) while information not directly linked to either the victim or the perpetrator was held constant (e.g., background items). Manipulations circled in blue identify the victim and manipulations circled in red identify the perpetrator as either in-group or out-group members. Participants saw these images without the circles.

two universities among the students. A posttest manipulation check verified the validity of our in-group/out-group identification measures. Participants were asked two questions: 1) How important is being a part of Indiana University to you? and 2) How important is being a part of Purdue University to you? Participants both affiliated significantly more with Indiana University as compared to Purdue University, and were able to successfully link each identified victim and perpetrator to their respective university.

We manipulated the images to create two ambiguous group conflict conditions: an in-group-victim ambiguous conflict condition (in which the victim was identified as being an in-group member, but the perpetrator's group membership was not identified), and an out-group-victim ambiguous conflict condition (in which the victim was identified as being an out-group member, but the perpetrator's group membership was not identified). We also had two salient group conflict conditions: a salient in-group conflict condition (in which both the victim and the perpetrator were both identified as being in-group members), and a salient out-group conflict condition (in which both the victim and the perpetrator were both identified as being out-group members). Thus, four conditions of interest were created: (1) Salient in-group conflict: both the victim and the perpetrator were members of the in-group (IU); (2) Salient out-group conflict: both the victim and the perpetrator were members of the out-group (PU); (3) In-group-victim ambiguous conflict: the victim was an in-group member (IU) and the perpetrator was unidentified; (4) Out-group-victim ambiguous conflict: the victim was an out-group member (PU) and the perpetrator was unidentified. The exact same items in each image were modified in the salient in-group and out-group conflict conditions (see Figure 1). Conflict condition (ambiguous or salient) was manipulated within-subjects (i.e., four slideshows depicted ambiguous group conflict, and four salient group conflict). Group membership

(Indiana University or Purdue University) was manipulated between subjects. Conflict conditions were presented in pseudorandom order across participants.

Introducing the misinformation

Approximately 24-hrs after viewing the original slideshows, participants listened to an audio-recording for each of the eight events to ostensibly remind them of the events they had seen the day prior (see Figure 2; see supplemental Figure 1). Each recording consisted of one sentence describing each of the slide images that participants had seen the day prior, totaling 50 sentences for each of the eight events. The events were presented in pseudorandom order. Critically, 12 of the 50 sentences for each event were inconsistent with what had been presented in the original slideshows (i.e., introducing misinformation), whereas the remaining 38 sentences were consistent with the slideshow). Consistent with previous research, the misinformation was not supplementary; it directly contradicted originally presented information (Lindsay & Johnson, 1989; Loftus et al., 1978; Okado & Stark, 2005; Zaragoza & Lane, 1994). Each sentence was read at a comparable pace (averaging 1 sentence every 4 s). Participants listened to the recordings using high-quality headphones, and all verified to the experimenter that they could hear the recordings after the first trial.

Measuring true and false memories

After listening to all eight audio-recordings, we asked participants 18 forced-choice recognition questions about each of the eight events they had witnessed (based on the methods by Stark et al., 2010). Participants were instructed to respond based only on their memory for information presented visually in the slideshows 24-hrs prior. Of the 18 questions, 12 corresponded to the images for which

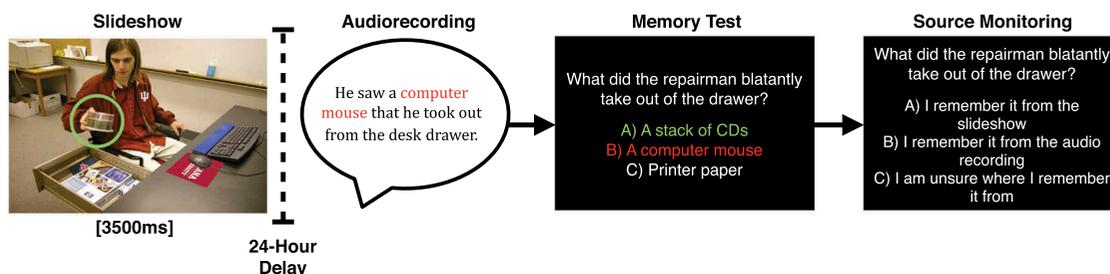


Figure 2. Order of events in Session 1 (e.g., Slideshow) and Session 2 (e.g., Audio-recording, Memory Test, Source-Monitoring; all of which were administered 24 hrs after the original encoding in Session 1). Slideshows were viewed during the original encoding in Session 1. Following a 24-hr delay, participants returned to the laboratory for Session 2. At this time, they heard corresponding audio-recordings, followed by a multiple choice memory test, and a source-monitoring test. The correct answer is defined as information that participants saw during the slideshow and is circled in green in the image. The incorrect "misinformation" answer is presented verbally during the narrative and is presented in red font. A true memory would be defined as choosing the correct answer "A stack of CDs" and attributing their memory to the slideshow on the source-monitoring test. A false memory would be defined as choosing the "misinformation" answer "A computer mouse" and incorrectly attribute their memory to the slideshow on the source-monitoring test.

misinformation had been provided, and six control questions corresponded to the images for which the audio-recording information was consistent with the slideshow. Although none of the test questions addressed group membership, a post-test manipulation check verified that all participants correctly identified the relevant group memberships in each condition. Participants viewed a cut out of each individual from each slideshow and were asked: "Where was [the victim/perpetrator] from?". Participants submitted their responses to the open-ended question by typing into the textbox. Participants correctly affiliated each individual from the slideshows to their corresponding school on 91% (SD = 12.46%) of the trials.

Each of the 18 questions was presented with three possible answer choices. For the misinformation questions, these were: the correct information presented in the slideshows, the misinformation presented in the audio-recordings, and one piece of unrelated information. For the control questions, these were: the correct information presented in the slideshows (that was also corroborated in the audio-recording), and two distinct unrelated pieces of information. Upon completion of the memory test, participants completed a source-monitoring test in which they attributed the source of their answers from the memory test to the slideshow from session 1, the audio-recording from session 2, or unknown (see Figure 2; see supplemental Figure 1).

Results

We excluded two participants (both from the salient in-group conflict condition) because their memory performance on the control questions was below chance (33.3%), which suggested poor memory overall. We identified true and false memories based only on the responses to the 12 misinformation items on the memory accuracy and source-monitoring tests (similar to the approach used by Carpenter & Schacter, *in press*; Okado & Stark, 2005; Stark et al., 2010). To be considered a false memory, participants had to select the answer on the memory accuracy test that corresponded to the misinformation item they had heard

during the audio-recording and attribute the source of their memory to the slideshow (thereby suggesting that the misinformation from the audio-recording was now incorporated into their original memory trace; see Figure 2). To be considered a true memory, participants had to select the answer on the memory accuracy test corresponding to the slideshow and attribute the source of their memory to the slideshows (see Figure 2). Other memories were those that did not meet the above criteria, and will not be discussed further.

False memory performance as a function of target and group membership

We subjected the number of false memories into a 2 (conflict type: ambiguous or salient) \times 2 (group membership: in-group or out-group) mixed analysis of variance (ANOVA). Results revealed a trend for an effect of conflict type ($F(1,49) = 3.28, p = .08, \eta^2_{\text{partial}} = .06$) and no effect of group membership ($F(1,49) = 1.27, p = .27, \eta^2_{\text{partial}} = .03$).

The predicted conflict type \times group membership interaction emerged, $F(1,49) = 4.67, p = .036, \eta^2_{\text{partial}} = .09$. Participants had more false memories in the salient in-group conflict condition ($M_{\text{False memories}} = 9.81, SD = 4.07$) than the salient out-group conflict condition ($M_{\text{False memories}} = 7.52, SD = 4.01; t(49) = 2.02, p = .049; 95\% \text{ CI } [.013, 4.56]$), the in-group-victim ambiguous group conflict condition ($M_{\text{False memories}} = 7.54, SD = 3.41; t(25) = 3.12, p = .004; 95\% \text{ CI } [.77, 3.77]$), and trending for the out-group-victim ambiguous group conflict condition ($M_{\text{False memories}} = 7.72, SD = 4.11; t(49) = 1.82, p = .074; 95\% \text{ CI } [-0.21, 4.39]$). The other conditions did not differ from each other (all $t_s < 1$).

True memory performance as a function of target and group membership

We next entered true memories into the same described ANOVA. There were no main effects, $F_s < 1, p_s > .74$ and no conflict type \times group membership interaction, $F(1,49) = 1.39, p = .24$. See Table 1 for means.¹

¹If the memory test were a simple recognition test—during which we gave participants three options (i.e., correct, misinformation, foil)—when there is an increase in false memories, there must be a decrease in the number of misses or a decrease in the number of true memories. However, during the source-monitoring task, participants are given three possible answer choices (i.e., the slideshow, the audio-recording, or unsure). It is important to note that an increase in false memories does not necessarily mean that the number of correct memories would decrease. Unlike simple recognition tasks in which participant responses are typically constrained to three possible response options (i.e., correct, misinformation, foil), there are not only three possible outcomes for source-monitoring paradigms that measure false memories. Rather, in the source-monitoring paradigm, a false memory is defined as trials for which participants both choose the misinformation item (out of three possible items) and attribute this information to the original (i.e., visual) source (out of three possible items), whereas a correct memory is defined as trials for which participants both choose the correct item (out of three items) and attribute this information to the original source (out of three items). By defining false memories this way (which is consistent with previous research utilizing the source-monitoring paradigm—for example, Carpenter & Schacter, *in press*; Okado & Stark, 2005), false memories and correct memories do not necessarily constrain one another in a source memory paradigm as they might in a recognition paradigm.

Table 1. Mean true memory in Experiment 1a and 1b. SD ().

	Indiana University (IG)	Purdue University (OG)
<i>Experiment 1a</i>		
Salient conflict	12.96 (5.85)	13.04 (7.34)
Ambiguous conflict	13.77 (5.54)	12.56 (6.77)
<i>Experiment 1b</i>		
Intragroup conflict	11.50 (4.22)	
Intergroup conflict	10.99 (4.85)	

IG: In-group, OG: Out-group.

Comparing memory errors pre- and post-crime realization

An important consideration in understanding how victim and/or perpetrator group membership might affect eyewitnesses' false memory rates for crime-related details is that the roles of victims and perpetrators are not always clearly defined from the beginning of a conflict. Thus, only once the conflict between the perpetrator and victim becomes apparent (which likely only occurs well into the crime taking place) would conflict resolution be necessary, resulting in the predicted increase in false memory. We therefore also examined whether false memories changed pre- as compared with post-crime realization across all of our experiments. If, for instance, intragroup conflict is associated with increased false memories because the conflict violates eyewitnesses' expectations, then false memories should be higher after the conflict has become salient.

Salient in-group versus out-group conflict may have elicited more false memories because participants may have been distracted by the nature of the intragroup conflict. If this is the case, the number of false memories should be exacerbated after the in-group (relative to the out-group) conflict became salient.

To examine this possibility, we compared the proportion of false memories post-crime realization (the second half of each event) with pre-crime realization (the first half) for the in-group and out-group salient conflict conditions. Participant feedback suggested that the halfway point in each event was when the victim and perpetrator roles became salient (see supplemental Figure 1). Because there were not equal numbers of misinformation questions for the first and second halves of each event, we calculated a proportion of false memories score by dividing the number of false memories in the respective half by the total number of questions asked about misinformation items in that half. These data were then entered into a 2 (time: pre crime-realization or post crime-realization) \times 2 (group membership: in-group or out-group) ANOVA. Main effects of time ($F(1,49) = 33.93, p < .001, \eta^2_{\text{partial}} = .41$) and

Table 2. Mean false memory in Experiment 1a and 1b for the 1st and 2nd Halves. SD ().

		Indiana University (IG)	Purdue University (OG)
<i>Experiment 1a</i>			
Salient conflict	1 st Half	.15 (.10)	.12 (.09)
	2 nd Half	.27 (.12)	.18 (.13)
Ambiguous conflict	1 st Half	.13 (.10)	.15 (.13)
	2 nd Half	.18 (.10)	.19 (.10)
<i>Experiment 1b</i>			
Intragroup conflict	1 st Half	.16 (.10)	
	2 nd Half	.26 (.11)	
Intergroup conflict	1 st Half	.19 (.11)	
	2 nd Half	.23 (.12)	

Intragroup conflict = Victim and Perpetrator: Indiana University (IG), Intergroup Conflict = Victim: Indiana University (IG), Perpetrator: Purdue University (OG).

group membership ($F(1,49) = 6.38, p = .02, \eta^2_{\text{partial}} = .12$) emerged (see Table 2 for means).

The predicted time \times group membership interaction also emerged ($F(1,49) = 5.10, p = .03, \eta^2_{\text{partial}} = .09$). There was a higher proportion of false memories post-crime realization as compared with pre- for the salient in-group conflict condition ($M_{\text{Change in false memories}} = .12, SD = .12$) versus the salient out-group conflict condition ($M_{\text{Change in false memories}} = .05, SD = .08; t(49) = 2.26, p = .03; 95\% \text{ CI } [.07, .03], d = .64$). No difference in the proportion of false memories between these two conditions occurred in the first half (salient in-group conflict: $M_{\text{False memories}} = .15, SD = .10$; salient out-group conflict: $M_{\text{False memories}} = .12, SD = .09; t(49) = 1.09, p = .28; 95\% \text{ CI } [-.03, .09], d = .30$). See Figure 3 for change in proportion of false memories from the 1st to the 2nd half.

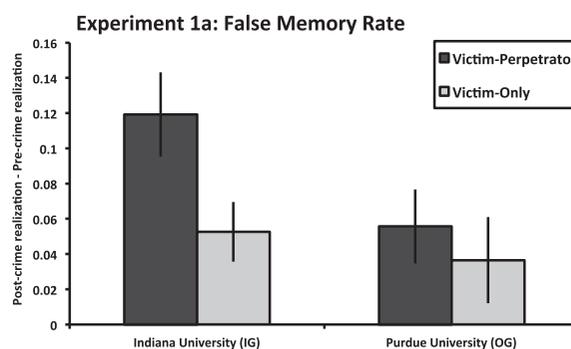


Figure 3. Change in the proportion of false memories from the 1st to the 2nd half for victim and perpetrator versus victim only conditions for both the in-group (IG: Indiana University) and out-group (OG: Purdue University). Results show significantly more false memories when both the victim and the perpetrator are identified as being in-group members during the 2nd half as compared to the in-group victim-only and both out-group conditions. Error bars SEM.

Experiment 1b

Experiment 1a suggests increased eyewitnesses susceptibility to false memories after intragroup conflict became salient. One limitation in that experiment, however, was that we did not examine whether salient *intergroup* conflict (e.g., when the group membership of the victim and perpetrator explicitly differs) also exacerbates false memories. Because heightened perceiver affiliation with a victim exacerbates perceived conflict, (e.g., Eidelman & Biernat, 2003; Marcus-Newhall et al., 2002; Marques & Yzerbyt, 1988; Nourkova et al., 2004; Pinto et al., 2010), we focused on crimes involving an in-group member as the victim, but manipulated the group membership of the perpetrator to be an in-group or out-group member. Given our focus on conflict salience, we predicted that false memories would be exacerbated once conflict was recognized (e.g., more false memories in the response to information presented in the second half of the events as compared to the first half).

Methods

A priori power analyses conducted using G*Power (Faul et al., 2009) indicated at least 21 participants would be necessary per condition to detect within-subject effects mirroring the time \times group membership effect size from Experiment 1b ($\eta_p^2 = .09$), $\alpha = .05$, and power = .95. Thus, 42 young adults ($M_{age} = 21$ years, $SD = 2.31$, 27 female) from Indiana University were recruited for Experiment 1b. They met the same eligibility criteria as outlined in Experiment 1a. Two participants were

excluded for failing to comply with task instructions (e.g., using the phone). No participants had memory below chance on the six control questions.

Experiment 1b replicated Experiment 1a with two differences. First, in order to streamline the task, we only included the six slideshows that depicted criminal activity (since the two control slideshows were not considered in the analyses anyway). Second, in order to compare false memories for salient intragroup and intergroup conflict, the perpetrator's group membership was either manipulated to be the same as the victim's (both in-group members) or different (mixed group membership). Conflict was manipulated within participant, and the intragroup and intergroup events were counterbalanced across participants (see Figure 4).

Results

False memory performance as a function of time and conflict type

As in Experiment 1a, we calculated the proportion of false memories pre- and post-crime realization to control for the fact that there was different number of critical items pre- and post- crime realization (which therefore would lead to the possibility for a different raw number of false memories overtime). A 2 (conflict type: intragroup or intergroup) \times 2 (time: pre crime-realization or post crime-realization) ANOVA on false memory rates revealed a main effect of time ($F(1,39) = 18.11$, $p < .001$, $\eta^2_{\text{partial}} = .32$; Pre-crime realization: $M_{\text{Intragroup}} = .16$, $SD = .10$; $M_{\text{Intergroup}} = .19$, $SD = .11$; Post-crime realization:



Figure 4. One of 50 images displayed in one slideshow, manipulated to identify both the victim and the perpetrator as in-group (i.e., intragroup conflict condition; Indiana University) members (i.e., identical Experiment 1a) or the victim as an in-group (i.e., Indiana University) and the perpetrator as an out-group member (i.e., intergroup conflict condition; Purdue University). Items identifying the perpetrator as an in-group member (the Indiana University logo on his jacket) and the victim as an in-group member (the computer mousepad and wallet) were held constant throughout the slideshow. Manipulations circled in blue identify the victim and manipulations circled in red identify the perpetrator as either in-group or out-group members. Participants saw these images without the circles.

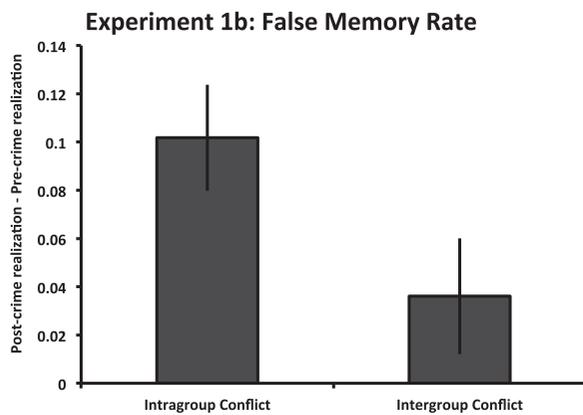


Figure 5. Change in the proportion of false memories from the 1st to the 2nd half for the intragroup conflict versus intergroup conflict conditions. Results show significantly more false memories when both the victim and the perpetrator are identified as being in-group members (i.e., intragroup conflict condition) during the 2nd half compared to the mixed victim-perpetrator 2nd half. Error bars SEM.

$M_{Intragroup} = .26$, $SD = .11$; $M_{Intergroup} = .23$, $SD = .12$). There was no main effect of conflict type ($F(1,39) < 1$, $p = .96$, $\eta^2_{partial} < .001$).

Consistent with Experiment 1a, a marginal conflict type \times time interaction emerged, $F(1,39) = 3.65$, $p = .06$, $\eta^2_{partial} = .09$). Although the interaction did not meet traditional levels of statistical significance, the directionality and effect size of these results replicated those in Experiment 1a. Specifically, the interaction was driven by the fact that there was a larger increase in the proportion of false memories from pre- to post-crime realization for the intragroup conflict condition ($M_{Change\ in\ false\ memories} = .10$, $SD = .15$) as compared with the intergroup conflict condition ($M_{Change\ in\ false\ memories} = .04$, $SD = .13$; $t(39) = 1.91$, $p = .06$; 95% CI [-.12, .003]; see Figure 5).

Discussion

The results of Experiments 1a and 1b suggest that eyewitnesses may be more susceptible to false memories for events depicting intragroup conflict (i.e., when both the victim and the perpetrator are in-group members).² Specifically, in Experiment 1a, we discovered that eyewitnesses reported more false memories after witnessing a crime depicting a victim and perpetrator who were in-group members relative to each other, and the eyewitness, as compared to when they witnessed a crime depicting two out-group members, or ambiguous group conflict. Moreover, the proportion of false memories increased post-crime realization as compared pre-crime realization, suggesting that the salience of the conflict may have been associated with increased false memories. Experiment 1b further shed light on these findings by suggesting that witnesses experience more false memories post-crime realization as compared to pre-crime realization, given crimes depicting intragroup versus intergroup conflict. Although consistent with the pattern from Experiment 1a, this relationship was marginally significant. However, it is important to note that both the directionality and effect size of the interaction in Experiment 1b replicated the results in 1a. Nevertheless, one possibility for the differences in levels of significance is that the difference in false memories between salient intragroup and intergroup conflict (Experiment 1b) may be weaker than the effects observed between ambiguous and salient group conflict (Experiment 1a).

Several possibilities may explain more false memories in the salient intragroup conflict condition versus both the in-group victim ambiguous conflict condition and the intergroup conflict condition. Salient intragroup conflict may divert eyewitnesses' attention

²An alternative explanation for the behavioral results shown thus far is that witnesses have more false memories when the eyewitness and the perpetrator are in-group members. If the in-group perpetrator were the source of the memory errors, then we would expect more memory errors in this condition. Alternatively, if the intragroup conflict created by seeing both the victim and the perpetrator as members of one's in-group engaged in conflict drove the increase in false memories, then we would expect to see no difference in false memories between the in-group perpetrator-only and the in-group victim-only conditions.

In order to test this, we recruited 28 young adults ($M_{age} = 21.75$ years, $SD = 2.49$, 17 female) from Indiana University to complete the same task described in Experiment 1a and 1b with the only difference being that only the perpetrator or only the victim's group membership was identified. Thus, each participant viewed four slideshows that depicted an in-group perpetrator with a non-identified victim (in-group perpetrator-only), and four slideshows that depicted an in-group victim with a non-identified perpetrator (in-group victim-only). These slideshows were presented in pseudorandom order across participants.

True memories were calculated in the same manner as described in Experiments 1a and 1b. Here we found that there were significantly more correct memories for the perpetrator only ($M_{True\ memories} = 15.64$, $SD = 6.30$) as compared to the victim only condition ($M_{True\ memories} = 13.79$, $SD = 6.05$; $t(27) = 2.43$, $p < .02$; 95% CI [.29, 3.43]).

False memories were calculated as described in Experiments 1a and 1b. There was no significant difference in the false memories for the perpetrator-only ($M_{False\ memories} = 7.39$, $SD = 5.68$) and victim-only ($M_{False\ memories} = 7.25$, $SD = 4.82$) conditions ($t(27) < 1$, $p = .82$; 95% CI [-1.17, 1.45]).

These findings suggest that identifying the perpetrator as an in-group member did not affect the number of false memories. Rather, the increase in the number of false memories observed in Experiments 1a and 1b was specific to the combination of both the victim and the perpetrator being identified as in-group members."

to the two group members, to either understand the discrepancy between observed actions and the expected actions of the two group members, or because the conflict itself was highly emotional. In either case, participants' attention may be diverted away from the details of the scene, resulting in weaker memory traces for these details, and greater susceptibility to false memories.³ Consistent with the latter interpretation, people show weaker memory for neutral peripheral elements of a scene given a highly emotional central event (Kensinger, Piquet, Krendl, & Corkin, 2005).

A limitation to using a behavioral approach to understand why salient intragroup conflict (relative to in-group victim ambiguous conflict) elicited more false memories is that both possibilities (e.g., heightened social salience related to the crime or heightened emotional salience) predict the same behavioral prediction: increased false memories. Because the neural mechanisms underlying social versus emotional salience have been well-characterized (e.g., Adolphs, 2009; Kensinger, 2009), we next leveraged neuroimaging to investigate why salient intragroup conflict increased false memories.

Several neuroimaging studies have evaluated false memories (for review, see Schacter & Slotnick, 2004) by focusing on differences during the retrieval of true and false memories (Cabeza, Rao, Wagner, Mayer, & Schacter, 2001; Okado & Stark, 2003; Schacter, Buckner, Koutstaal, Dale, & Rosen, 1997; Schacter et al., 1996), rather than the contribution of mechanisms during encoding to subsequent false memories (but, see Gonsalves et al., 2004; Okado & Stark, 2005; Paller & Gonsalves, 2000). As a result, it remains unknown whether increased activation in a specific set of neural regions during encoding reliably predicts false memories. However, the dissociable neural regions engaged in response to social as compared to emotionally salient information have been well-identified. We therefore had two goals in Experiment 2: first, to determine whether intragroup conflict increased social or emotional salience during encoding; and second, to identify the neural regions engaged during encoding that predicted subsequent false memory.

Experiment 2

To determine whether salient intragroup conflict increased eyewitnesses' false memories for crimes by increasing the emotional or social salience of the crime we designed and implemented an fMRI study. If conflict elicited increased emotional salience, perceivers' attention may have been drawn to the emotional element of a scene (the conflict), and away from peripheral, nonemotional details (the details of the crime), thereby resulting in a memory trade-off (for review, see Kensinger, 2009). Indeed, eyewitnesses have more powerful affective responses to crimes committed by in-group versus out-group perpetrators (Marcus-Newhall et al., 2002). However, the intragroup conflict may increase false memories by augmenting the conflict's social salience. That is, participants may have focused on trying to understand why two in-group members were in conflict. Supporting this idea, people have worse memory for negative behaviors about in-group versus out-group members, suggesting a weaker memory trace for expectation-inconsistent behaviors (Howard & Rothbart, 1980).

Our neuroimaging experiment sought to disentangle the roles of emotional and social salience on false memories for crimes involving salient intragroup conflict. A benefit to utilizing neuroimaging here is that the neural correlates of emotional and social salience are each comprised of distinct networks (e.g., Adolphs, 2009; Cloutier, Gabrieli, O'Young, & Ambady, 2011; Kensinger, 2009; Murty, Ritchey, Adcock, & LaBar, 2010). Specifically, emotionally salient information engages the amygdala, fusiform gyrus, inferior frontal gyrus, and lingual gyrus (Adolphs, Denburg, & Tranel, 2001; Adolphs, Tranel, & Buchanan, 2005; Kensinger & Schacter, 2006; Murty et al., 2010; Waring & Kensinger, 2011), while the anterior cingulate cortex (ACC), dorsomedial prefrontal cortex (dmPFC), precuneus, inferior frontal gyrus, and bilateral temporoparietal junction interact when evaluating social information (e.g., Cloutier et al., 2011).

If emotional salience disrupts memory given intragroup conflict, we expected heightened activation in the emotional salience network (e.g., amygdala,

³The important distinction between a true and false memory is the incorporation of post-event misinformation in the memory for the original event. While remembering contradictory information presented in the audio-recording as coming from the slideshow results in a false memory, we are not arguing that the original memory trace is replaced or forgotten. Rather, when the original memory trace is weakened, participants may be more likely to incorporate post-event misinformation (please see the description on page 4 of the manuscript). However, if a discrepancy is detected or the post-event misinformation is not incorporated into the memory of the original event, we argue that the original memory trace may still be retrieved. However, there are many other factors after the encoding phase that may affect whether or not the original trace will be successfully retrieved. Thus, our results are only able to comment on the effect of social salience during encoding of the original event; however, we acknowledge that future work should evaluate the continuous interaction between encoding and retrieval in relation to the current results.

fusiform gyrus, inferior frontal gyrus, and lingual gyrus) when individuals viewed crimes involving in-group members. If, however, this conflict disrupts memory via social salience, we predicted heightened activation in neural regions associated with cognitive conflict, such as the ACC (Kerns et al., 2004).

Materials and methods

Participants

In order to parallel the sample size in Experiment 1b, we recruited 39 right-handed young adults without neurological or psychiatric diagnosis ($M_{age} = 21.6$ years, $SD = 2.2$ years, 26 female) from Indiana University who participated for monetary compensation. One participant was excluded from analyses due to excessive movement. The Indiana University IRB approved this study.

Materials

The methods and materials are the same as described in Experiment 1a, with three exceptions: first, as in Experiment 1b, we only presented participants with the six crimes, each with 50 events (resulting in 300 events per participant); second, conflict condition was manipulated between subject; and third, encoding of the original event took place while participants simultaneously underwent fMRI. The second session (introduction of misinformation and memory task) was conducted outside the scanner.

fMRI procedure

Anatomical and functional whole-brain imaging was performed on a 3.0 T Siemens Trio Scanner (Trio, Siemens Ltd., Erlangen, Germany) using standard data acquisition protocols. Anatomical images were acquired using a high-resolution 3-D magnetization prepared rapid gradient echo sequence (MP-RAGE; 160 sagittal slices, $TE = 2.67$ ms, $TR = 2000$ ms, flip angle = 9° , $1 \times 1 \times 1$ mm voxels). Functional images were collected in six functional runs of 163 time points each, using a fast field echo-planar sequence sensitive to blood-oxygen level-dependent contrast ($T2^*$) (35 axial slices per whole-brain volume, 3 mm in-plane resolution, 3.8 mm thickness, 0 mm skip, $TR = 2000$ ms).

Data analysis

fMRI analyses

fMRI data were analyzed using the general linear model for event-related designs in SPM8 (Wellcome Department

of Cognitive Neurology, London, UK). Data underwent standard preprocessing to remove sources of noise and artifact. Preprocessing and analyses of functional data were conducted in SPM8 (Wellcome Trust Centre for Neuroimaging, London, UK). Images were realigned to correct for motion, normalized to the Montreal Neurological Institute (MNI) template, and spatially smoothed (8 mm full-width-at-half-maximum [FWHM]) using a Gaussian kernel. Using custom artifact detection software to detect motion artifact (http://www.nitrc.org/projects/artifact_detect), individual runs were analyzed on a participant-by-participant basis to find outlier time points. Specifically, we excluded volumes during which participant head motion exceeded 1 mm and volumes in which the overall signal for that time point fell three SDs outside the mean global signal for the entire run. Outlier time points were excluded from the GLM analysis via the use of participant-specific regressors of no interest.

Analyses were conducted on two levels: GLM and ROI analyses. GLM analyses incorporated separate task-specific regressors for critical information trials that later became a true memory, false memory, neither a true nor a false memory, and all noncritical information, along with covariates of no interest (a session mean, a linear trend, and six movement parameters derived from realignment corrections). These regressors were used to compute parameter estimates (β) and t-contrast images (containing weighted parameter estimates) for each comparison at each voxel and for each subject. Region of interest (ROI) analyses were conducted using the functional ROIs tool in SPM8 (marsbar; <http://marsbar.sourceforge.net/>). Each ROI was extracted by using the contrast from each condition relative to baseline fixation to conduct a region of interest (ROI) analysis.

Functional connectivity was examined using the generalized psychophysiological interactions (gPPI; <http://brainmap.wisc.edu/PPI>; McLaren, Ries, Xu, & Johnson, 2012) toolbox in SPM8. The gPPI toolbox automatically accommodates multiple task conditions in the same PPI model and compares functional connectivity with a single seed region across conditions. Each seed region was used to create volumes of interest (VOIs) for each subject by creating a 6 mm sphere around this peak coordinate. Within each subject, the gPPI toolbox was used to estimate functional connectivity across the entire brain with the seed region in the four memory type conditions (i.e., true memory, false memory, generic, or guess) and to calculate 2 contrasts of interest (True memory > False memory and False memory > True memory). The generic memory condition was used to define trials for which no corresponding information was presented in the narrative (i.e., could not result in a false memory).

At the group level, contrasts from each of the individual-subject gPPIs were entered into separate single-sample *t*-tests. The first set of contrasts identified regions more positively correlated with the seed region for true memories as compared to false memories. The second set of contrasts identified regions more positively correlated with the seed region for false memories as compared to true memories.

We had two main goals in the fMRI analyses. First, we examined how conflict condition affected the neural activity underlying subsequent true and false memories. Second, we examined how patterns of neural activity differed by conflict condition (salient intragroup conflict versus in-group-victim ambiguous conflict) and by time (pre-crime realization versus post-crime realization), irrespective of subsequent memory. We were unable to consider subsequent memory for the latter analyses because many participants did not have a sufficient number of false memories in just the pre- or post-crime realization conditions to detect reliable differences.

With respect to the subsequent memory analysis for our first goal, we excluded five participants because they had fewer than five true memories, and six others because they had fewer than five false memories (see Okado & Stark, 2005, for similar exclusionary criteria). This left 27 remaining participants ($M_{age} = 21.4$ years, $SD = 2.1$ years, 19 female), 14 of whom had been pseudorandomly assigned to the intragroup conflict condition, and 13 of whom were assigned to the ambiguous conflict condition. Given the relatively small sample size in this condition, data were extracted at a threshold of $p < .005$ using a more conservative 15-voxel extent threshold (see Woo, Krishnan, & Wager, 2014 for discussion on cluster thresholding).

Importantly, subsequent memory performance did not place any constraints on our sample size with respect to our second goal of examining the effect of condition pre- and post- crime realization. Thus, these results are reported with the full sample of 38 participants (16 = intragroup conflict condition, 22 = ambiguous conflict condition). Thus, an additional benefit of this analysis was that it allowed us to validate the results from the smaller subsequent memory sample with a sample that was more than one-third larger at a more conservative threshold of $p < .001$ uncorrected, with 10 contiguous voxels.

Results

Behavioral results

False memories. We first conducted a *t*-test to compare the overall number of false memories in the salient and

ambiguous conflict conditions. Replicating Experiment 1a, there were more false memories in the intragroup conflict condition ($M_{False\ Memory} = 14.19$, $SD = 6.40$) than the ambiguous conflict condition ($M_{False\ Memory} = 8.55$, $SD = 4.39$; $t(36) = 3.23$, $p = .003$).

We conducted 2 (conflict type: ambiguous or salient) \times 2 (time: pre-crime realization or post-crime realization) mixed ANOVA with proportion false memories as the dependent variable. As with Experiments 1a and 1b, we used proportion false memories here because the number of possible items for which participants could have had false memories differed pre- and post-crime realization. Replicating Experiment 1a, there was a main effect of condition, $F(1,36) = 8.64$, $p = .006$, $\eta^2_{partial} = .19$, because there were more false memories in the intragroup conflict condition versus the ambiguous conflict condition ($M_{Intragroup} = .20$, $SD = .09$; $M_{Ambiguous} = .12$, $SD = .06$; $t(36) = 3.23$, $p = .003$). There was a main effect time, $F(1,36) = 13.09$, $p = .001$, $\eta^2_{partial} = .27$, and a trending interaction between time and conflict condition (salient intragroup or ambiguous), $F(1,36) = 2.81$, $p = .10$, $\eta^2_{partial} = .07$. Although this interaction was marginal, the directionality of the effects and the overall effect size replicated the pattern of results from both Experiment 1a and Experiment 1b. Critically, replicating our results in Experiment 1a, there were more false memories over-time in the salient intragroup as compared to the ambiguous group conditions ($M_{Intragroup} = .23$, $SD = .11$; $M_{Ambiguous} = .13$, $SD = .09$; $t(36) = 3.01$, $p = .005$).

True memories. We conducted a separate *t*-test to compare the overall number of true memories in the salient and ambiguous conflict conditions. Like Experiment 1a, there was no difference in the number of true memories for the intragroup conflict ($M_{True\ Memory} = 22.19$, $SD = 11.32$) as compared to the ambiguous conflict conditions ($M_{True\ Memory} = 19.64$, $SD = 11.91$; $t(36) < 1$, $p = .51$).

fMRI results

Effects of conflict condition on subsequent memory

We first examined how conflict condition affected neural activity underlying subsequent true and false memories using a 2 (conflict condition: intragroup or ambiguous) \times 2 (memory type: true or false) whole-brain ANOVA using the respective task > baseline contrasts for each variable. Results revealed a main effect of memory type in the left superior frontal gyrus (BA 6; Table 3), such that this region was more active when

Table 3. Main effects of memory type, main effect of conflict condition, and memory type × conflict condition interaction that emerged from the 2 (conflict condition: intragroup or ambiguous) × 2 (memory type: true memory or false memory) whole-brain voxelwise ANOVA.

Brain Region	x	y	z	Kextent	T-score
Main effect of memory					
<i>True Memory > False Memory</i>					
Left superior frontal gyrus (BA 6)	-21	6	72	27	3.92
Left anterior cingulate cortex (BA 32)	-21	12	39	23	2.60
<i>False Memory > True Memory</i>					
No significant voxels					
Main effect of conflict condition					
<i>Intragroup conflict > Ambiguous conflict</i>					
Left superior frontal gyrus (BA 10)	-24	63	12	34	3.14
Right superior frontal gyrus (BA 8/10)	3	39	57	129	4.05
Right superior frontal gyrus (BA 6/8)	27	30	57	64	3.35
Right middle frontal gyrus (BA 10)	42	57	6	203	4.47
Right dmPFC (BA 9)	18	57	42	27	3.53
Right dlPFC (BA 9/46)	42	45	33	173	5.01
Left dlPFC (BA 46)	-48	39	33	56	3.76
Right orbitofrontal cortex (BA 11)	15	57	-15	18	3.2
Left orbitofrontal cortex (BA 11)	-24	45	-18	94	4
Right middle frontal gyrus (BA 11)	36	36	-21	49	3.62
Left inferior frontal gyrus (BA 47)	-18	36	-6	*	3.22
Right inferior frontal gyrus (BA 47)	27	18	-12	*	4.07
Left Anterior cingulate (BA 32)	-12	30	-6	24	3.24
Right superior temporal gyrus (BA 38)	18	15	-33	181	5.57
Left parahippocampal gyrus (hippocampus)	-24	-12	-21	*	3.16
Right parahippocampal gyrus (BA 19/30)	24	-45	0	97	3.58
Left sub-gyral (BA 20)	-39	-15	-21	33	3.33
Left parahippocampal gyrus (BA 30)	-6	-36	6	*	3.15
Right middle temporal gyrus (BA 39)	51	-72	15	53	3.4
Left middle temporal gyrus (BA 39)	-45	-75	27	*	3.08
Left inferior parietal lobule (BA 40)	-30	-39	39	74	3.52
Right inferior parietal lobule (BA 40)	45	-45	60	1797	5.82
Left cingulate gyrus (BA 31)	-21	-45	21	96	3.61
Left fusiform gyrus (BA 37)	-60	-48	-18	91	4.08
Right cuneus (BA 17)	9	-78	12	16	3.21
Right cuneus (BA 19)	18	-93	42	356	3.82
Left middle occipital gyrus (BA 19)	-39	-84	21	56	3.99
Left lingual gyrus (BA 18)	-15	-102	-6	33	3.09
Left cerebellum	0	-63	-30	24	3.42
Left cerebellum	-33	-72	-42	2450	5.99
<i>Ambiguous conflict > Intragroup conflict</i>					
No significant voxels					
Memory type X conflict condition					
<i>Ambiguous conflict True memory > False memory</i>					
Right inferior parietal lobule (BA 40)	54	-30	30	61	2.97
Right postcentral gyrus (BA 3)	33	-36	48	25	3.4
<i>Intragroup conflict True memory > False memory</i>					
Left superior temporal gyrus (BA 38)	-24	24	-33	21	3.32

Subcluster activations noted with *. Organized by region anterior to posterior. Coordinates are MNI.

individuals evaluated images that were subsequently remembered. No region was more active for items that were subsequently falsely remembered.

A main effect of conflict condition elicited a wide range of neural activity, including bilateral dorsolateral prefrontal cortex (BA 46), right middle and superior frontal gyrus (BA 6/8/11), right inferior frontal gyrus (BA 47), right middle and superior temporal gyrus (38/39), right parahippocampal gyrus, bilateral inferior parietal lobule (BA 40), and visual processing regions including fusiform gyrus and right cuneus (see Table 3 for complete list of activations). These regions were more active in the intragroup conflict versus ambiguous

conflict conditions. No regions were more active toward ambiguous conflict versus intragroup conflict conditions. The only peak emerging from the memory type × conflict condition interaction was within left postcentral gyrus (BA 1/2; see Table 3).

Effects of crime realization and conflict condition on neural activity

To identify neural activity differing pre- and post-crime realization in the intragroup conflict versus the ambiguous conflict conditions, we conducted a 2 (conflict condition: intragroup or ambiguous) × 2

(time: pre-crime realization v. post-crime realization) whole-brain ANOVA using all trials in which participants viewed critical information (i.e., specific items for which they later received misinformation). A main effect of conflict condition elicited activity in bilateral precuneus, ACC, dmPFC, and fusiform gyrus (see [Table 4](#) for complete list of activations). These heightened activations were driven by activity toward intragroup versus ambiguous conflict. No regions were more active for the ambiguous versus intragroup conflict conditions. A main effect of time emerged in regions broadly associated with social cognition, including dmPFC, orbitofrontal cortex, and right temporoparietal junction. These activations were driven by the post-crime versus pre-crime realization. No regions were more active pre-crime realization as compared to post (see [Table 4](#) for complete list of activations). No regions emerged in the conflict condition \times time interaction.

T-test comparing intragroup and ambiguous conflict post-crime realization

Because behavioral analyses revealed a significant interaction for false memories (driven by a greater increase in false memories from pre-crime realization to post-crime realization for the intragroup conflict condition as compared with the ambiguous conflict condition), we conducted a *t*-test to directly compare the neural activation in the two conflict conditions during post-crime realization. Post-crime realization, participants in the intragroup conflict condition (as compared to the ambiguous conflict condition) had greater activation in neural regions associated with social cognition, including in the right ACC, bilateral inferior frontal gyrus, bilateral fusiform gyrus, and bilateral precuneus (see [Figure 6](#); and [Table 5](#) for complete list of activations). No regions were more active post-crime realization in the ambiguous conflict condition as compared to the intragroup conflict condition.

Regions exhibiting differential neural connectivity with the anterior cingulate cortex as a function of subsequent false memories

The above results demonstrated that participants in the intragroup conflict condition (as compared to the ambiguous conflict condition) had greater activation post-crime realization in neural regions associated with intragroup conflict, including in the right ACC and bilateral inferior frontal gyrus (Amodio, 2014). Because prior work has widely implicated the ACC in conflict resolution (e.g., Kerns et al., 2004), we

investigated which neural regions were functionally coupled with the ACC for items that were subsequently falsely remembered (using gPPI). We conducted this analysis for both conflict conditions by creating a seed region for the right ACC peak emerging from the *t*-test contrasting the two conflict conditions post-crime realization (3, 33, 24; see [Table 5](#)). We then identified neural regions that were functionally coupled with those regions on items for which participants in the intragroup conflict condition had a subsequent false (as compared to true) memory. We conducted the same analysis for participants in the ambiguous conflict condition. For the intragroup conflict condition, we found heightened functional connectivity between the right ACC and the right dmPFC (see [Table 6](#)). For the ambiguous conflict condition, however, the rACC was functionally coupled with the posterior cingulate, and not the dmPFC. See [Figure 7](#).

Discussion

Results revealed evidence of neural activation in regions associated with processing social salience (i.e., ACC, dmPFC), which predicted participants' subsequent false memories. Although these results emerged from analyses on a smaller subset of our data (because not all participants had a sufficient number of false memories), the same pattern of results emerged when we compared neural activation post- as compared to pre-crime realization on the full dataset. Specifically, we found heightened activation in regions associated with social salience (including ACC) post-crime realization in the intragroup conflict condition. Functional connectivity analyses demonstrated that the ACC was functionally coupled with dmPFC. Thus, both analyses provide converging evidence that false memories from intragroup conflict emerge because the conflict elicits increased social, not emotional, salience.

General discussion

Results of these experiments suggest that individuals are more susceptible to false memories after witnessing crimes depicting salient intragroup conflict versus salient out-group conflict, or mixed-group conflict (with an in-group or out-group victim). Our neuroimaging findings suggest that the social salience of the intragroup conflict may be associated with increased susceptibility to false memories. Specifically, we found heightened activation in neural regions associated with social salience (e.g., ACC and dmPFC), but not emotional salience, in the salient intragroup conflict condition. Further, activity in these regions was more

Table 4. Main effects of conflict condition, time, and conflict condition \times time interaction that emerged from the 2 (conflict condition: intragroup or ambiguous) \times 2 (time: pre-crime realization or post-crime realization) whole-brain voxelwise ANOVA.

Brain Region	x	y	z	Kextent	T-score
Main effect of conflict condition					
<i>Intragroup > Ambiguous</i>					
Left dmPFC (BA 9/10)	-3	63	24	115	4.5
Right dlPFC (BA 10)	33	63	3	51	4.4
Right superior frontal gyrus (BA 10)	21	57	-9	12	3.92
Left medial frontal gyrus (BA 8)	-3	54	42	40	3.87
Right superior frontal gyrus (BA 8)	45	18	51	44	4.08
Right superior frontal gyrus (BA 8)	30	36	51	24	3.74
Right superior frontal gyrus (BA 9/10)	42	42	30	150	5.23
Left superior frontal gyrus (BA 6)	0	36	60	38	4.18
Left middle frontal gyrus (BA 8)	-42	30	39	24	3.73
Left middle frontal gyrus (BA 6)	-36	-3	48	29	3.87
Right middle frontal gyrus (BA 6)	18	-12	57	6499	5.71
Right fusiform gyrus (BA 20)	57	-33	-21	*	5.51
Left anterior cingulate gyrus (BA 32)	-3	21	42	231	4.32
Left middle temporal gyrus (BA 38)	-45	9	-42	17	3.65
Right transverse temporal gyrus (BA 41)	33	-39	12	23	4.02
Right middle temporal gyrus (BA 19)	51	-75	18	11	3.57
Left parahippocampal gyrus (BA 36)	-24	-21	-30	10	3.66
Right inferior parietal lobule (BA 40)	39	-30	39	83	4.28
Right inferior parietal lobule (BA 7/40)	45	-54	60	327	5.36
Left inferior parietal lobule (BA 40)	-33	-54	36	36	3.81
Left superior parietal lobule (BA 7)	-42	-57	60	29	3.67
Left precuneus (BA 7)	-6	-78	39	440	4.84
Right precuneus (BA 7)	18	-81	51	15	3.43
Left cerebellum	0	-60	-42	41	3.87
<i>Ambiguous > Intragroup</i>					
<i>No significant voxels</i>					
Main effect of time					
<i>Post-crime realization > Pre-crime realization</i>					
Left superior frontal gyrus (BA 10)	-33	60	-3	56	4.41
Right anterior cingulate (BA 32)	3	33	24	160	4.62
Left middle frontal gyrus (BA 46)	-48	39	33	24	4.15
Right inferior frontal gyrus (BA 45/47)	60	15	0	112	5.35
Right inferior frontal gyrus (BA 47)	39	15	-6	127	4.69
Right precentral gyrus (BA 6)	30	-12	57	77	4.91
Left insula (BA 13)	-39	18	3	195	5.48
Right postcentral gyrus (BA 2)	30	-24	36	52	4.72
Left postcentral gyrus (BA 3)	-27	-30	60	30	4.14
Left inferior parietal lobule (BA 40)	-51	-48	48	18	3.94
Right superior parietal lobule (BA 7)	45	-57	60	86	5.38
Left fusiform gyrus (BA 20)	-48	-30	-30	75	4.44
Right fusiform gyrus (BA 20)	42	-21	-24	97	5.43
Right uncus (BA 36)	24	-12	-39	*	4.92
Right parahippocampal gyrus (BA 36)	27	-18	-27	*	3.72
Left uncus (BA 36)	-21	-9	-39	142	4.73
Left parahippocampal gyrus (BA 36)	-27	-18	-24	*	4.67
Left superior temporal gyrus (BA 42)	-69	-30	12	25	4.2
Left middle temporal gyrus (BA 21)	-69	-33	-6	*	3.88
Right inferior temporal gyrus (BA 20/21)	60	-33	-21	225	6.91
Right inferior temporal gyrus (BA 20)	57	-60	-15	22	3.99
Left precuneus (BA 7/24)	0	-36	45	275	4.88
Left precuneus (BA 7)	-6	-78	39	33	4.12
Right precuneus (BA 7)	9	-69	42	57	4.35
Right lingual gyrus (BA 17)	21	-102	-9	25	3.92
Right thalamus	3	-12	3	18	4.27
Right lentiform nucleus	15	-9	-3	22	3.86
Right cerebellum	33	-42	-39	60	4.64
Left cerebellum	-42	-51	-39	49	4.4
Right cerebellum	45	-75	-42	52	4.09
<i>Ambiguous conflict > Intragroup conflict</i>					
<i>No significant voxels</i>					
Memory type \times conflict condition					
<i>No significant voxels</i>					

Subcluster activations noted with *. Organized by region anterior to posterior. Coordinates are MNI.

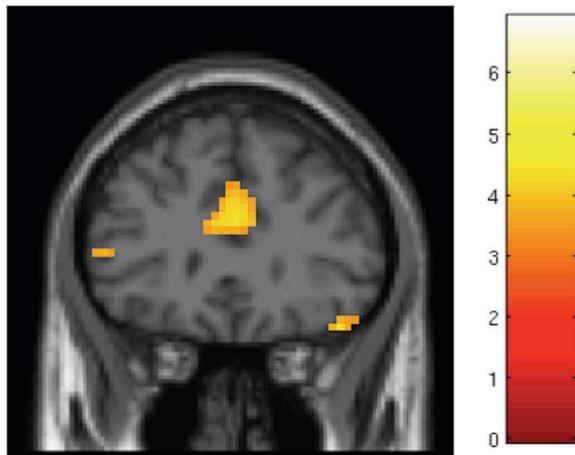


Figure 6. T-test results showing increased activation in the rACC during the critical trials in intragroup conflict as compared to ambiguous conflict conditions post-crime realization.

pronounced after the nature of the conflict became clear (e.g., post-crime realization).

The current study extends the literature on false memories in several important ways. Of central importance, prior research has not evaluated the role in which the identification of specific individuals within

an event affects participants' susceptibility to source misattributions. The current study suggests crimes involving a victim and perpetrator who have the same group membership to each other, and (critically) to the eyewitness, may elicit more false memories.

Second, our results demonstrated that false memories overall increased from pre-crime realization to post-crime realization. That is, even when controlling for differences in the number of memories assessed from pre-crime realization to post-crime realization (by using a proportion score), our results across Experiments 1a, 1b, and 2 demonstrated that participants overall had more false memories in post-crime realization than pre-crime realization, and this effect was specifically exacerbated for crimes depicting intragroup conflict. The present research therefore provided support for the role of conflict resolution in memory for events specifically involving intragroup conflict.

The neuroimaging results in Experiment 2 further elucidated the mechanisms underlying our findings. Participants in the intragroup conflict condition (as compared to the ambiguous conflict condition) had heightened activation post-crime realization in neural regions associated with social cognition, notably those

Table 5. Regions that were more active as a function of conflict condition post-crime realization.

Brain Region	x	y	z	Kextent	T-score
<i>Ambiguous conflict > Intragroup conflict</i>					
<i>No significant voxels</i>					
<i>Intragroup conflict > Ambiguous conflict</i>					
Left superior frontal gyrus (BA 10)	-33	60	-3	56	4.41
Left dlPFC (BA 46)	-48	39	33	24	4.15
Left inferior frontal gyrus (BA 46)	-54	36	6	14	4.04
Right ACC/dmPFC (BA 32)	3	33	24	160	4.62
Left insula (BA 13)	-39	18	3	195	5.48
Right inferior frontal gyrus (BA 45)	60	15	0	112	5.35
Right inferior frontal gyrus (BA 47)	39	15	-6	127	4.69
Left insula (BA 13)	-30	-33	24	14	3.88
Right lentiform nucleus	15	-9	-3	22	3.86
Right precentral gyrus (BA 6)	30	-12	57	77	4.91
Right thalamus	3	-12	3	18	4.27
Right parahippocampal gyrus (BA 36)	27	-18	-27	*	3.72
Left parahippocampal gyrus (BA 36)	-27	-18	-24	142	4.67
Right fusiform gyrus (BA 20)	42	-21	-24	97	5.43
Left fusiform gyrus (BA 20)	-48	-30	-30	75	4.44
Right postcentral gyrus (BA 2)	30	-24	36	52	4.72
Left postcentral gyrus (BA 3)	-27	-30	60	30	4.14
Left superior temporal gyrus (BA 21/42)	-69	-30	12	25	4.2
Right inferior temporal gyrus (BA 20/21)	60	-33	-21	225	6.91
Right inferior temporal gyrus (BA 20)	57	-60	-15	22	3.99
Left inferior parietal lobule (BA 40)	-51	-48	48	18	3.94
Right superior parietal lobule (BA 7)	45	-57	60	86	5.38
Left lingual gyrus (BA 18)	-12	-51	3	14	3.8
Right lingual gyrus (BA 17)	21	-102	-9	25	3.92
Left precuneus (BA 7)	0	-36	45	275	4.88
Left precuneus (BA 7)	-6	-78	39	33	4.12
Right precuneus (BA 7)	9	-69	42	57	4.35
Right cerebellum	33	-42	-39	60	4.64
Right cerebellum	45	-75	-42	52	4.09
Right cerebellum	15	-78	-33	11	3.6
Left cerebellum	-42	-51	-39	49	4.4

Subcluster activations noted with *. Organized by region anterior to posterior. Coordinates are MNI.

Table 6. Regions that were functionally coupled with the right ACC for participants in the intragroup conflict condition when they viewed critical items for which they subsequently had a false (as compared to true) memory. Coordinates are MNI.

Brain Region	x	y	z	Kextent	T-score
<i>Ambiguous conflict condition</i>					
Left posterior cingulate (BA 31)	-18	-54	24	16	4.73
Left dlPFC (BA 10)	-30	42	21	15	4.49
<i>Intragroup conflict condition</i>					
Left middle frontal gyrus (BA 6)	-15	9	51	59	4.58
Right dmPFC	18	18	51	56	4.08

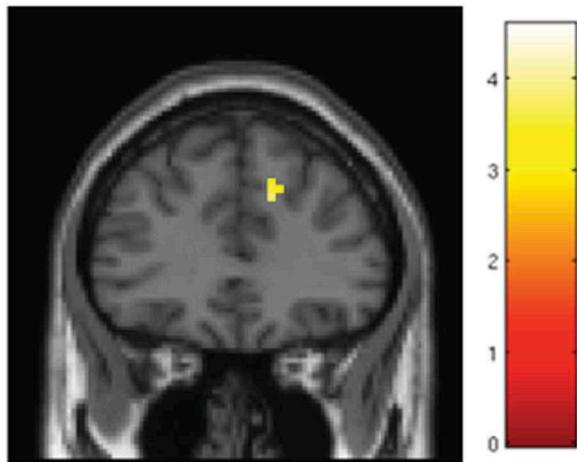


Figure 7. Activity in the dmPFC was functionally coupled with the right ACC when participants in the intragroup conflict condition viewed items for which they later had false (as compared to true) memories.

involved with resolving conflicts. Specifically, comparing neural activation in the two conflict conditions post-crime realization revealed heightened activation in ACC—a region that has been widely implicated in conflict monitoring and the engagement of cognitive control (e.g., Kerns et al., 2004)—and the inferior frontal gyrus—a region broadly implicated in initiating cognitive control in social judgments (e.g., Amodio, 2014). The ACC has also been implicated as being more engaged when participants view social targets that they perceive to be more similar to themselves (Leshikar, Cassidy, & Gutches, *in press*). Moreover, a functional connectivity analysis revealed that heightened activation in the ACC was associated with heightened functional coupling in the dmPFC when participants in the intragroup conflict condition evaluated items for which they subsequently had false memories. This coupling was not present in the ambiguous conflict condition. Thus, one possible, albeit speculative, explanation for this pattern of results is that during intragroup conflict, participants may be trying to resolve the discrepancy between their expectation of how in-group members should act and the witnessed actions of said in-group members, which

may disrupt their ability to accurately encode the details of the crime, thereby increasing their susceptibility to false memories. Consistent with this speculation, participants in the intragroup conflict condition also experienced more false memories post-crime realization as compared to participants in the ambiguous conflict condition.

Our results are consistent with previous research on false memory (e.g., Cabeza et al., 2001; Kim & Cabeza, 2007; Okado & Stark, 2003), demonstrating the role of the prefrontal cortex, temporal lobes, and parietal cortex in encoding information that subsequently becomes a true as compared to a false memory. Notably, this research has shown that the prefrontal cortex, parietal cortex, and late visual processing regions are engaged when individuals encode information for which they subsequently form a true or false memory (e.g., Kim & Cabeza, 2007; Okado & Stark, 2003). However, the posterior medial temporal lobes (e.g., notably the parahippocampal gyrus), and early visual areas are more active when individuals encode information that later becomes a true memory (Cabeza et al., 2001; Kim & Cabeza, 2007; Okado & Stark, 2003).

At first glance, our finding that intragroup conflict increased false memories for details related to the crime by increasing the social salience of the conflict appears to be consistent with extensive research on the memory trade-off effect (for review, see Hamann, 2001). Simply put, when participants evaluate emotional scenes, they have enhanced memories for central item-specific details about a negative event or scene, but their memory accuracy for neutral, peripheral details is disrupted (for review, see Kensinger, 2009). However, an important distinction in the current investigation is that although emotionally salient information may enhance memory for specific details, social information (e.g., impression incongruities) may lead to meta-perceptions about the conflict itself and result in similar heightened false memory rates. Importantly, social salience would only affect participants' memory for items presented once the conflict becomes apparent (i.e., post-crime realization). However, there are many other factors after the encoding phase that may affect whether or not the original trace will be successfully retrieved. Thus, our results are only able to comment on the effect of social salience during encoding of the original event. Future work should evaluate the continuous interaction between encoding and retrieval in relation to the current results.

Our finding that intragroup conflict increased the social salience of the crime is consistent with previous research on the Black Sheep Effect, which suggests that perceivers feel less affiliation with in-group members

who violate social norms, but stronger affiliation with in-group victims of social norm violations (Eidelman & Biernat, 2003; Marcus-Newhall et al., 2002; Marques & Yzerbyt, 1988; Nourkova et al., 2004; Pinto et al., 2010). This polarized response may be more robust when an in-group member is victimized by another in-group member (e.g., Eidelman & Biernat, 2003). That is, intragroup conflict may increase susceptibility to false memories because perceivers may fixate on the social aspect of the conflict rather than distancing themselves from the in-group perpetrator (e.g., resolving the expectation-based incongruity associated with seeing two in-group members in conflict). Consistent with this interpretation, recent research suggests that individuals have better memories for impressions they form of people they perceive to be similar to themselves, but only provided the impressions are positive (e.g., Leshikar, Dulas, & Duarte, 2015; Leshikar, Park, & Gutchess, 2015), which is likely not the case in the intragroup conflict condition.

Although we can only speculate as to the reasons why participants' proportion of false memories increased post-crime realization, one intriguing possibility that should be examined in future research is that the increase in false memories reflects the effect of increased arousal or stress on memory. That is, participants might have found the event information to be more stressful and/or arousing when it occurred post-crime realization because that is when they understood that they were viewing a crime. In support of this assertion, we found that events presented post-crime realization (regardless of conflict condition) were more susceptible to false memories than those presented pre-crime details. However, the fact that intragroup conflict exacerbated these effects suggests that the conflict might have introduced even more arousal and/or stress. Indeed, valence and arousal have both been widely shown to affect memory (e.g., Kensinger & Corkin, 2004), as has stress (see Vedhara, Hyde, Gilchrist, Tytherleigh, & Plummer, 2000). Future research using psychophysiological measures should disentangle these possibilities.

An important limitation of this study is that we did not measure participants' memory for faces. Therefore we cannot discount the alternate possible interpretation that participants' had more misinformation in the intragroup conflict condition because they allocated more attentional resources to in-group faces as compared to out-group faces (e.g., Ito & Urland, 2005; Trawalter, Todd, Baird, & Richeson, 2008). However, prior research showing a memory enhancement for in-group as compared to out-group faces has focused primarily on race (Golby, Gabrieli, Chiao, & Eberhardt,

2001). In the current study, the victims, perpetrators, and participants were Caucasian. Future research should nonetheless examine this alternate interpretation. It is important to note that the misinformation on which the false memories were based stemmed from questions about the peripheral details of the crime, not about the perpetrators or the victims themselves. Therefore, eyewitnesses may have had better memories for the central details of the crimes (e.g., the perpetrator or the victim), and their increased false memories for the peripheral details may result from a memory trade-off. However, because we did not manipulate the central or peripheral details in the current study, this possibility is speculative. Future research should examine this question, with respect to whether memory for the central details of the crimes (e.g., the in-group victim and in-group perpetrator) is enhanced. Further, future research should utilize eye-tracking in concert with fMRI methods in order to better understand the role of attention allocation in response to both emotional and social salience and how the potential patterns of attention diversion affect subsequent false memory for both central and peripheral details.

A related limitation to the current research is that the stimuli we used did not allow us to disentangle whether witnesses' increased susceptibility to false memories post-crime (as compared to pre-crime realization) affected their overall ability to accurately identify the perpetrator. In the current study, we were constrained by the limitations of the stimuli used in prior studies. Thus, future research may develop a more tightly controlled stimuli set that could address the question of whether the overall gist of the witness' memory (e.g., based on the pre-crime realization details) is sufficient to ensure that the perpetrator is properly identified.

Second, our in-group/out-group manipulation focused solely on University affiliation, while in real-world scenarios there are likely multiple group membership features (e.g., gender, race, etc.) that affect individuals' affiliation with the in-group. Thus, future research should evaluate how the level of affiliation within the in-group (i.e., university affiliation versus both university affiliation and gender affiliation) may affect subsequent memory.

There are several limitations to the standard misinformation paradigm. First, each participant evaluated many different events, and several variables were manipulated within subject. It is possible that presenting several events involving intragroup conflict between two in-group members affected participants' expectations for future events. Namely, participants may have expected intragroup conflict in all events as compared to an

unidentified individual or an out-group member in conflict with a member of the in-group. However, the presentation of the slideshow events and the misinformation audio-recordings was randomized, so any confounds associated with general expectation violation would be washed out. Additionally, participants were presented with multiple events depicting criminal activity, while in a real-world situation it seems highly unlikely that participants would witness six consecutive events depicting conflict. However there are two features of our experimental design that speak against the possibility that exposure to multiple slideshows affected the reported results. First, the randomization of both the order of the event slideshows and the misinformation narratives would diminish the effects of fatigue or overexposure. Second, the slideshows and audio-recordings have been reliably used to evaluate false memories both behaviorally and using neuroimaging methods in several previous studies (Okado & Stark, 2005; Stark et al., 2010).

Together, the results from the current study contribute to the growing body of literature on false memories in eyewitness testimony. Specifically, our results demonstrated that the group membership of the victim and the perpetrator involved in a crime influences eyewitnesses' susceptibility to false memories by increasing the social salience of the event during the encoding phase. While the current results suggest that memories for details related to crimes are malleable and can be influenced by group membership during the encoding phase, future research should investigate additional mechanisms that may play a role during the misinformation and retrieval phases.

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Disclosure statement

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Author contributions

A. Carpenter and A. Krendl developed the study concept and design. Testing and data collection were performed by A. Carpenter. A. Carpenter and A. Krendl conducted the analyses.

A. Carpenter drafted the manuscript, and A. Krendl provided critical revisions. Both authors approved the final version of the manuscript for submission.

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