Sources and Destinations of Misattributions in Recall of Instances of Repeated Events

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Abstract

Repeated experience of events promotes schema formation. Later activation of the schema facilitates recall of the general structure of the events, whereas attribution of details to specific instances requires systematic decision-making based on detail characteristics. For repeated events, source monitoring may be less effective due to the similarity and interference of details across instances and consequently results in source attribution errors. To date, researchers have examined aggregated misattributions across instances and have found that misattributions are more frequent in the middle than in the boundary instances. In this study, we investigated the specific trajectories of misattributions using data from six studies (N = 633), where participants recalled repeated interactive marketing-themed events (Study 1), mock-crime filmed events (Study 2), stories (Study 3), and categorized word-lists (Studies 4 – 6). The patterns confirmed the expected primacy and recency effects, showing fewer misattributions from and to the boundary instances relative to the middle instances. In addition, the patterns indicated proximity effects: Confusions more frequently occurred across adjacent instances and gradually decreased for instances that were further apart from the source. Our findings suggest that detail characteristics that form the basis of source attribution decisions provide information about the relative position of instances in repeated events, where the boundary instances serve as anchors, and where confusion relatively easily occurs across neighbouring instances. In line with context-based models of memory, our findings indicate that a higher-level organization of repeated events that emerges at encoding guides retrieval and source monitoring decisions.

Key words: source monitoring, misattribution, repeated events

Sources and Destinations of Misattributions in Recall of Instances of Repeated Events

Three friends had a conversation about a language course. Jeana missed three classes over the past two weeks, so John and Barbara briefed her about the content. John said: "On the first day you missed, we learnt about past tenses. Next time, we received a surprise test, and at the last class, the teacher brought up future tenses". Barbara corrected him, as she remembered that they took the surprise test at the last class and already began learning future tenses two weeks ago. Who was right? Both, to a degree. The test and introduction to future tenses took place at the same class two weeks ago. What happened is that both John and Barbara misattributed when certain activities occurred.

Misattributions Across Instances of Repeated Events

Similar experiences facilitate the generation of a schema (Hard et al., 2006; Nørby, 2015; Rumelhart et al., 1986; Schank, 1999; van Kesteren et al., 2013). At recall, the schema provides a general structure of instances, while decisions regarding attribution of specific details to individual instances require systematic evaluation of various detail characteristics that may provide source links (Johnson et al., 1993; Lindsay, 2008, 2014). The schema and interference of details across repeated experiences may, however, make discrimination between instances difficult (Lindsay, 2008); in the words of James (1901), details of repeated experiences may "form too confused a cloud" (p. 673). Indeed, misattributions frequently occur during the recall of instances of repeated events (Woiwod et al., 2019).

Instances, however, differ in the degree of source confusion according to their temporal position within the repeated event. The first instance, compared to the following instances, typically contains a higher proportion of accurately attributed details (e.g., Deck & Paterson, 2021; Dilevski et al., 2020a; 2020b; MacLean et al., 2018). This primacy effect is likely a result of the novelty of the first instance and its role in establishing the repeated event (Robinson, 1992), where these unique source attributes help effective source monitoring.

Although the following instances are unique to a degree (i.e., each contains specific details), their experience is fundamentally different from that of the first instance. Due to their overlap in content and structure, the following instances are likely reflected upon as other similar instances (e.g., Farrar & Boyer-Pennington, 1999; Farrar & Goodman, 1990; Slackman & Nelson, 1984). The consequence of this schema-confirmation process may be the generation of source attributes that, instead of linking details to a specific instance, provide only broad links to the overall repeated event (Rubínová et al., In Press). Such broad links to the middle instances then manifest both as source confusions and as changes in detail attribution across multiple retrieval attempts (i.e., contradictory source attributions in reports of instances; Rubínová et al., In Press). The final instance typically includes a higher proportion of accurately attributed details than the middle instances (Dilevski et al., 2020b). However, this recency effect is smaller than the primacy effect associated with the first instance. The specific role of the final instance in concluding the repeated event provides some unique attributes, although these attributes do not grant complete immunity against source interference.

To date, researchers have examined only aggregated misattributions across instances (e.g., total misattributions in the recall of each instance). Such analyses are consistent with the current understanding of organization of memory for repeated events in which lower-level details accumulated across repeated experiences are clustered within categories that constitute the higher-level knowledge about the repeated events (i.e., the sequence of typical activities, places, participants, etc.) rather than within specific instances (see Hudson & Mayhew, 2009). The primacy and recency effects described above are compatible with this view—the first and final experiences may be more memorable as individual instances. But what if memory organization for repeated events is more refined, incorporating the specific sequence of instances and facilitating instance memory? If such finer organization existed, misattributions across instances would likely follow a pattern. However, such pattern cannot be examined with aggregated misattributions. There are high-stake real-world cases, where understanding the way that memory for repeated events works is important, including (but not limited to) criminal and civil investigations (e.g., abuse cases, sexual harassment), and institutional and industrial investigations (e.g., healthcare safety, near miss incidents). Gaining insight into the predictability of memory errors can inform investigators' expectations and interviewing of victims and witnesses in such cases. Therefore, our aim in this study was to explore the specific trajectories of misattributions in recall. Examining the specific patterns of sources of misattributions (i.e., which instances misattributions come from) and destinations of misattributions (i.e., which instances are misattributions recalled in) can indicate regularities with implications on the current view of how memory for repeated events is organized.

In the next section, we briefly summarize key findings from two relatively remote fields where the common task of participants is to make decisions about the temporal position of recalled elements that originally occurred in a sequence (a task similar to recalling details of instances of repeated events). Primacy and recency effects typically manifest both in short-term serial-recall tasks and in long-term recall of dates of autobiographical events. In addition, there are further regularities in the error patterns that may shed light on our investigation.

Error Patterns in Short- and Long-Term Recall

Rememberers in short-term serial-recall tasks are often asked to recall items from a list in the order in which they were presented. The typical performance indicates that participants recall items but confuse the order, and that items from the middle of a list are more prone to order confusions than items at its boundaries (e.g., Bjork & Healy, 1974; Healy, 1974). A close examination of error patterns of order-recall additionally reveals that participants most frequently confuse the order of adjacent items (Healy, 1974; Lee & Estes, 1977). These findings inspired the development of memory models, which assume that temporal (order) attributes are represented in memory in the form of the relative position of items, where the relative position to boundary items plays the most important role (e.g., Estes, 1985; Henson, 1998). Temporal attributes are subject to perturbation processes, which may occur during re-encoding following the rehearsal of items or over longer delays. Perturbations most frequently occur across adjacent items and decrease as the distance between items increases (Lee & Estes, 1981), creating error gradients that serve as evidence of the proximity effect.

Similar patterns frequently occur in tasks where rememberers are asked to estimate dates of autobiographical events. Transitional events (e.g., moving to a new city; N. R. Brown, 2016) and first-time experiences (e.g., starting a new job; Robinson, 1992) typically serve the role of temporal landmarks in the organization of autobiographical memory. In line with the primacy effect, dating these landmark events and the events associated with them is usually more accurate than for other events (e.g., Loftus & Marburger, 1983; Shum, 1998). Temporal recency is also observed, in that dating of recent events is usually more accurate than dating of remote events (e.g., Rubin & Baddeley, 1989). In addition, dating errors most frequently occur around the actual date or day of the week, indicating a proximity effect (Betz & Skowronski, 1997; Larsen & Thompson, 1995). The proximity effect is explained by the hierarchical structure of temporal memory representations. For example, when dating events that occurred in the past few weeks, one may first think about the day of the week the event occurred (e.g., Monday or Saturday). Temporal schemata associated with specific events may constrain the search to a specific day or days of the week (e.g., hiking trips typically occur during the weekend). Associations with local temporal landmarks or period boundaries then guide the final temporal decision on a specific day (e.g., Thompson et al., 1993).

Both tasks described above indicate that errors in the estimation of the temporal position can be linked to available information about the relative position of an element in the context of the event or period. Finding similar patterns for misattributions reported within instances of repeated events would inform our understanding of the processes that accompany the experience of repeated events and consequently form the basis of source monitoring decisions during recall (e.g., Lindsay, 2008).

Current Study

We explored misattribution patterns at recall of instances of repeated events in a secondary analysis of data from the authors' six previously published experiments (Kontogianni et al., 2021; Rubínová et al., In Press; Rubínová et al., 2021; Rubínová et al., 2020). All studies employed the repeated event paradigm with four instances but varied in the nature of the stimuli (e.g., interactive/filmed events, stories, categorized word-lists), the procedure (e.g., instances occurred on separate days or in a single session), delay until recall (e.g., ten minutes to two weeks), and the number of recall sessions (e.g., one to four). All studies additionally examined effects of content or order changes introduced as part of one of the instances (i.e., deviations). These changes had none or only small effects on recall of correct details (for further details, see Kontogianni et al., 2021; Rubínová et al., In Press; Rubínová et al., 2021; Rubínová et al., 2020), were not of primary interest in the current study, and we had no expectations that they would impact the misattribution patterns. Therefore, we collapsed data across all conditions in the current study.[1]

[1] To check whether the changes influenced the misattribution patterns, we provided Figures SM1 and SM2 in the Online Supplemental Materials. These figures display the source and destination patterns, respectively, for a subset of data that involved no deviation manipulations. The patterns in Figures SM1 and SM2 are almost identical to those presented in this manuscript for data collapsed across conditions.

When examining the sources of misattributions, we looked at the composition of recall of individual instances and traced where confusions came from; when examining the destinations of misattributions, we looked at instance-specific details and traced where they were reported. What would the primacy, recency and proximity effects look like in the distribution of misattributions?

The primacy and recency effects would generally limit misattributions from the boundary instances. In recall of Instance 1, due to the recency effect, misattributions from Instance 4 would be lower than misattributions from Instances 2 and 3, which would be similarly high. In recall of Instance 4, the primacy effect would limit misattributions from Instance 1, which would be lower than misattributions from Instances 2 and 3 (these would be similarly high). In recall of Instance 2, the primacy effect would be strong thus limiting misattributions from Instance 1, while a relatively weak recency effect would limit misattributions from Instance 4 to a lesser degree; misattributions from Instance 3 would be highest. The pattern would be similar for recall of Instance 3, where misattributions from Instance 2 would be highest, followed by misattributions from Instance 4 that would be limited due to the weaker recency effect, and then misattributions from Instance 1 that would be limited to a greater degree due to the stronger primacy effect.

The proximity effect would lead to a pattern where the proportion of misattributions depends on the distance between instances. For example, in recall of Instance 1, misattributions from Instance 2 would be highest, followed by misattributions from Instance 3 and then from Instance 4, and the pattern would be reversed for recall of Instance 4. In recall of Instance 2, misattributions from the adjacent Instances 1 and 3 would be similar and higher than misattributions from Instance 4, which occurred further away. Similarly, in recall of Instance 3, misattributions from the adjacent Instances 2 and 4 would be similar and higher than misattributions from Instance 1. Note that all three effects would suggest lowest misattributions from the boundary instances; therefore, the proximity effect would be indicated by differences in misattributions from the middle Instances 2 and 3, respectively in the reduction of the primacy/recency effects where a boundary instance is also an adjacent instance.

To summarize, the primacy and recency effects would generally limit misattributions from Instances 1 and 4 but are not expected to impact misattributions from Instances 2 and 3 (i.e., we might expect similar misattributions from the middle instances in recall). The proximity effect would impact misattributions based on the proximity of instances in that misattributions across neighbouring instances would be more frequent than misattributions across instances that were not neighbours.

Method

In the following sections, we provide brief summaries of the methods of Studies 1 – 6. For more details regarding samples, procedures, and results pertaining to other measures than the distribution of source attribution errors, see Rubínová (2020b) and Rubínová et al. (In Press) for Study 1, Kontogianni et al. (2021) for Study 2, Rubínová et al. (2021), for Study 3, Rubínová (2020a) for Study 4, and Rubínová et al. (2020) for Studies 5 and 6. Because the current study used data from previously published studies, no a-priori power analysis was conducted.

Study 1

Study 1 was a 4 (Instance: 1/2/3/4) × 2 (Recall Session: 1 to 2 weeks/1 month after presentation) within-subjects design. There were additional between-subjects factors: 2 (Content: Typical/Deviation) × 2 (Order: Typical/Deviation) that were collapsed for the purpose of the current study.

Participants experienced four structured interactive visits (i.e., instances) during which they evaluated products as part of three activities (board game play, packaging design evaluation, and device inspection; the specific items were different each time). These visits occurred on separate days with one- to four-day intervals. One to two weeks after the final visit (*M* = 9.51 days, *SD* = 2.37), participants were interviewed. They were asked to recall as many details as possible from each of the four visits without guessing. One month later (*M* = 35.70 days, *SD* = 6.70), participants completed an online recall form with four pages including the visit designation and the same instructions. Each visit included 12 specific details.

Data for the original study were entered and validated manually, and inter-rater agreement was high (Cohen's kappa for various detail categories was ≥ .90; Rubínová et al., In Press). Validated data were then automatically coded as accurate attributions or misattributions using custom-defined functions in R (i.e., the current study did not involve any manual coding).

Study 2

Study 2 was a 4 (Instance: 1/2/3/4) × 3 (Reporting Format: Multi-Method Interviewing Format/Self-Generated-Cues & Timeline/Free Recall) × 2 (Deviation: Present/Absent), with Instance as a within-subjects factor and Reporting Format and Deviation as between-subjects factors. The Deviation factor had little impact on recall, and the Reporting Format factor impacted on a quantitative measure of recall but there were no differences across Reporting Formats in the number of reported misattributions (aggregated) or on recall accuracy (see Kontogianni et al., 2021). We collapsed across the between-subjects factors because they were not of primary interest in this study.

Over separate sessions, participants were asked to imagine that they were an agent infiltrating a "terrorist group" and viewed four scripted films (i.e., instances) depicting the planning of a series of "attacks". Each film included an indoor meeting scene where the leader of a group delivered instructions to three other perpetrators, and an outdoor scene

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where the group executed the plan by planting explosives in four different locations. Each instance contained unique details pertaining to the target, timing, explosive, and other aspects of the attack. The procedure of stimuli presentation was the same as in Study 1. Participants came in for an interview one week after the final film was presented (*M* = 7.29 days, *SD* = 0.53).

In this study, participants were asked to imagine that they were an undercover agent infiltrating the group depicted in the events, so the information they provided should be as detailed and accurate as possible. Across conditions, participants were asked to provide an overview of all the events they witnessed first. When using a timeline, participants could do so by tagging each event with a coloured marker to label them. Moreover, across format conditions, participants spontaneously labelled the events with the outdoor location which differed across instances. They were not cued to each instance or corrected when they reported fewer than four instances. Afterwards, across format conditions, participants were asked to report all the details they remembered about the events and the people involved, and to report exactly what was said when possible but not make guesses about things they did not remember. In the Multi-Method Interviewing Format and Self-Generated-Cues & Timeline Format conditions, participants were asked to list six details that immediately come to mind on a sheet of paper for each instance. They were asked to use a separate timeline for each instance but not told how many to use (timelines were stacked on the side). In the Free Recall Format, participants were provided with a booklet with multiple sheets of paper. In the Multi-Method Interviewing Format and Free Recall format conditions, participants were then asked between 3 and 5 open prompts per reported instance (e.g., “You mentioned there was a blonde man. Tell me more about this blonde man.”).

Misattributions were coded for any reported detail or description that was unique to an instance and was reported in an incorrect instance. This was mainly due to the complexity and variability of the stimuli, which involved dialogues and actions of multiple actors. Inter-rater agreement reported in Kontogianni et al. (2021) was high (intra-class correlation of .97).

Study 3

Study 3 was a 4 (Instance: 1/2/3/4) × 2 (Recall Session: 10 minutes/1 day/1 week/1 month after presentation) within-subjects design. As in Study 1, there were between-subjects factors: 2 (Content: Typical/Deviation) × 2 (Order: Typical/Deviation) that were collapsed for the purpose of the current study.

Participants were presented with four videos of stories (i.e., instances) depicting the arrangement of a ceremony similar to a wedding (adapted from Ahn, Mooney, & Brewer, 1992). All stories were presented in a single session using the following procedure: Story 1 was played twice, then participants completed a one-minute filler task, then they completed an isolated recall of Story 1 (this rehearsal was excluded from the current study), and then they engaged in a two-minute filler task. The procedure repeated until participants completed the isolated recall of Story 4. After a 10-minute filler task, participants were asked to recall all four stories using separate pages headed with the story designation and illustration of the two main characters. The same procedure was used during the next three recall sessions that participants completed online one day, one week, and one month later.

Each story included 11 specific details. Inter-rater agreement reported in the original study was high (Cohen's kappa between .72 and .89; Rubínová et al., 2021), and coding for this study was done automatically.

Studies 4, 5, and 6

The design was the same as in Study 3; Study 6 included only two recall sessions (10 minutes and 1 day after stimuli presentation). Data were collapsed across content and order manipulation conditions.

Participants were presented with four categorized word-lists (i.e., instances; each 9-word list comprised of words from 3 ordered categories) shown on different background colours following the procedure described under Study 3. There was one exception: the isolated recall of each list was not administered in Study 4 (i.e., after the one-minute filler task, participants proceeded to the two-minute filler task without recall of the list). In Studies 4 and 5, participants were told that they would see lists of words that a student learned on four consecutive days, and a photograph of the student was presented at the beginning of each list. The lists were designated by the day of the week (i.e., Monday to Thursday); in Study 6, participants were told that they would see four lists that were designated by ordinal numbers (i.e., 1 to 4). During recall sessions, participants were cued by the list designation, background colour, and in Studies 4 and 5 also the student's photograph.

Statistical Analyses

Data were analyzed at the level of weighted proportions of misattributions reported at each instance, recall session, and experiment. Each reported misattribution had three potential sources (e.g., a misattribution reported in Instance 1 had Instances 2, 3, and 4 as potential sources), and each misattribution had three potential destinations (e.g., misattribution originating at Instance 2 had Instances 1, 3, and 4 as potential destinations). Therefore, we built eight linear models, using the `stat` package in R (R Core Team, 2020): four models for each of the four instances where misattributions were reported (for the analyses of sources), and four models for each of the four instances where misattributions originated (for the analyses of destinations). The aim in our analyses was to examine the differences between the proportions of misattributions between pairs of potential sources (or destinations), and the potential changes in these differences across recall sessions and studies.

For the analyses of sources/destinations, each model included source/destination (a categorical variable with three levels), recall session, study, and the two-way interactions between (i) source/destination and recall session and (ii) source/destination and study as predictor variables. All predictor variables were coded with successive difference contrasts (Schad et al., 2020) from the `MASS` package (Venables & Ripley, 2002). Specifically, for study, the contrasts compared successive pairs of studies (e.g., Study 1 vs 2, Study 2 vs 3, etc.), and for recall session, the contrasts compared successive pairs of recall sessions (e.g., Recall Session 1 vs 2, Recall Session 2 vs 3, etc.). For source/destination, the contrasts compared successive pairs of levels (e.g., for analyses of sources of misattributions in recall of Instance 1, the contrasts were Instance 2 vs 3 and Instance 3 vs 4; for recall of Instance 2, the contrasts were Instance 1 vs 3 and Instance 3 vs 4). To control for error rate for multiple tests run in each model (i.e., 26 *p*-values in each model), we computed a boundary value for a false discovery rate (Benjamini & Hochberg, 1995) and only considered *p*-valued below this boundary as significant.

Regression coefficients show the mean differences in the percentage points of proportions and are reported along with 95% Confidence Intervals in brackets to indicate the range of their plausible values (Cumming, 2012, 2014). We also reported Cohen's *d* and associated 95% Confidence Intervals to aid interpretation of the sizes of the effects (package `effectsize`; Ben-Shachar et al., 2020).

We used packages `ggplot2` (Wickham, 2016) and `extrafont` (Chang, 2014) for visualizations, package `boot` (Canty & Ripley, 2021) for computing bootstrapped Confidence Intervals, and packages `psych` (Revelle, 2020), `reshape2` (Wickham, 2007), and `dplyr` (Wickham et al., 2020) for data management. Supplemental materials containing complete results, data, and R scripts are available online [https://osf.io/9gsy4/?view_only=261c285c89ac4c1db4edf6ab033fbfb7].

Results

Sources of Misattributions

To examine the trajectories of misattributions, we first looked at recall of individual instances and traced the sources of misattributions. The patterns of the sources of misattributions averaged across studies and recall sessions are displayed in Figure 1. The patterns of recall of Instances 1, 3, and 4 most clearly represent the proximity effect: participants misattributed higher proportions of details from instances that occurred near rather than further away.

[INSERT FIGURE 1 HERE]

In the boundary Instances 1 and 4, there was a gradual decrease in misattributions with an increase in the distance from the source. In recall of Instance 1, the proportions of misattributions from Instance 2 were higher than the proportions of misattributions from Instance 3, $b = 0.26$ [0.22, 0.29], $t(24) = 14.28$, $p < .001$, $d = 1.28$ [1.10, 1.47], and the proportions of misattributions from Instance 3 were higher than the proportions of misattributions from Instance 4, $b = 0.13$ [0.07, 0.19], $t(24) = 4.79$, $p < .001$, $d = 0.65$ [0.37, 0.93]. There were also two significant interactions between source and recall session, and between source and study, both in the contrast between misattributions from Instances 2 and 3. The first interaction indicated a moderating effect of recall session on the difference between the proportions. As shown in the top left panel of Figure 2, this difference was greater in Recall Session 1 than in Recall Session 2, $b = 0.14$ [0.06, 0.21], $t(24) = 3.79$, $p < .001$, $d = 0.69$ [0.31, 1.06]. The second interaction indicated differences between Studies 2 and 3. As shown in the top left panel of Figure 3, there were small differences between the sources of misattributions recalled in Instance 1 in Study 2 (statistics are reported in Online Supplemental Materials). Other contrasts and interactions were not significant after correction for multiple tests (*p*s > .031).

[INSERT FIGURE 2 HERE]

In recall of Instance 4, the pattern was inverse to Instance 1: proportions of misattributions from Instance 3 were higher than proportions of misattributions from Instance 2, $b = 0.35$ [0.32, 0.39], $t(24) = 19.25$, $p < .001$, $d = 1.48$ [1.32, 1.64], and the proportions of misattributions from Instance 2 were higher than the proportions of misattributions from Instance 1, $b = 0.14$ [0.07, 0.20], $t(24) = 4.36$, $p < .001$, $d = 0.58$ [0.30, 0.85]. There was also a significant interaction between source and recall session showing a moderating effect of the recall session described above: the difference in the proportions of misattributions from Instances 2 and 3 were more pronounced in Recall Session 1 than in Recall Session 2 (see the bottom right panel of Figure 2), $b = 0.10$ [0.04, 0.16], $t(24) = 3.63$, $p < .001$, $d = 0.43$ [0.19, 0.68]. There were also three significant interactions between source and study indicating that the difference between the proportions of misattributions from Instances 2 and 3 was more pronounced in Study 4 compared to Studies 3 and 5 and in Study 6 compared to Study 5 (see the bottom right panel of Figure 3; statistics are reported in Online Supplemental Materials). Other contrasts and interactions were not significant after correction for multiple tests (ps > .017).

[INSERT FIGURE 3 HERE]

In the middle Instance 3, Figure 1 indicates that the proportions of misattributions from the two nearby Instances 2 and 4 were greater than the proportions of misattributions from Instance 1, which occurred further away—a pattern consistent with the proximity effect. The proportion of misattributions from Instance 2 was higher than the proportion of misattributions from Instance 1, $b = 0.27$ [0.21, 0.33], $t(24) = 8.96$, $p < .001$, $d = 2.22$ [1.71, 2.73]. The difference in the proportions of misattributions from Instances 2 and 4 reported in Instance 3 was not significant after the correction for multiple comparisons (p = .024). A significant interaction between source and recall session indicated that the difference in the proportion of misattributions from Instances 2 and 4 was greater in Recall Session 2 than in Recall Session 1, b = 0.13 [0.07, 0.19], t(24) = 4.63, p < .001, d = 1.11 [0.61, 1.61] (see the bottom left panel of Figure 2). There were three significant interactions between source and study. As is visible in the top right panel of Figure 3, two interactions indicated that the pattern of misattributions from Instances 1 and 2 was in the opposite direction in Study 2 than in Studies 1 and 3, and the final interaction indicated that the difference between misattributions from Instances 2 and 4 was greater in Study 3 than in Study 4 (statistics are reported in Online Supplemental Materials). There were no further significant contrasts or interactions after the correction for multiple comparisons (ps ≥ .013).

The misattribution pattern for the middle Instance 2 (Figure 1) is partly consistent with the proximity effect, indicating a greater proportion of misattributions from a nearby Instance 3 than from the farther Instance 4, but the proportion of misattributions from the other neighbouring Instance 1 was lowest among all the sources—a pattern consistent with the primacy effect. The proportion of misattributions from Instance 3 was higher than the proportion of misattributions from Instance 1, b = 0.29 [0.24, 0.33], t(24) = 13.03, p < .001, d = 1.33 [1.12, 1.54], and Instance 4, b = 0.25 [0.20, 0.29], t(24) = 11.53, p < .001, d = 1.15 [0.94, 1.36]. There were three interactions between source and recall session. As shown in the top right panel of Figure 2, two interactions indicated that the differences were greater in Recall Session 1 than in Recall Session 2 for misattributions from Instances 1 and 3, b = 0.11 [0.03, 0.19], t(24) = 2.82, p = .009, d = 0.52 [0.14, 0.90], and also for misattributions from Instances 3 and 4, b = 0.17 [0.10, 0.25], t(24) = 4.77, p < .001, d = 0.80 [0.45, 1.15]. A further interaction indicated that the difference in misattributions from Instances 3 and 4 were more pronounced in Recall Session 3 than in the final Recall Session 4, $b = 0.13$ [0.03, 0.23], $t(24) = 2.72$, $p = .012$, $d = 0.61$ [0.15, 1.08]. Finally, almost all interactions between source and study were significant. A close inspection of the top right panel of Figure 3 indicates that the misattribution patterns in Study 2 differed from Studies 1 and 3 (i.e., the pattern in Study 2 was mostly flat). For the rest of the comparisons, the interactions indicated variability in the magnitude of the differences in misattributions from Instances 1 and 3, respectively Instances 3 and 4 while the overall patterns remained consistent.

Overall, the misattribution patterns in the boundary Instances 1 and 4 showed a gradual decrease of misattributions from Instances 2 and 3 indicating proximity, and so did the misattribution pattern in Instance 3. Primacy and recency effects are consistent with the lowest proportions of misattributions from Instances 1 and 4 in the boundary Instances 1 and 4, and the primacy effect is also consistent with the lowest proportion of misattributions from Instance 1 reported in Instances 2 and 3. The recency effect does not seem to be involved in the misattribution pattern in Instance 3. For Instance 2, the misattribution pattern is consistent with the primacy and recency effects (which limit misattributions from Instances 1 and 4). Although misattribution patterns were highly consistent across recall sessions, interactions systematically indicated moderation—the differences in sources of misattributions were generally more pronounced in the first than in the second recall session. Finally, the patterns were highly consistent across studies except for Study 2, where misattribution patterns were not very pronounced and indicated some proximity effect but little primacy or recency effects; other interactions between source and study typically indicated variability in the magnitude of differences between the sources but not differences in the patterns.

Destinations of Misattributions

We also examined the trajectories of misattributions from the perspective of their destinations, i.e., we traced details of each instance that were not accurately reported as occurring in that instance and looked at where these misattributions were reported instead. The overall patterns of destinations of misattributions in Figure 4 indicate a clear proximity effect: details were most frequently misattributed to instances that occurred near and decreased with distance. The pattern for details from Instance 2 additionally indicated an involvement of the primacy effect, and the pattern for details from Instance 3 indicated an involvement of a weak recency effect.

[INSERT FIGURE 4 HERE]

For details from Instance 1, higher proportions were misattributed to Instance 2 than Instance 3, $b = 0.25$ [0.19, 0.30], $t(24) = 9.53$, $p < .001$, $d = 1.57$ [1.23, 1.91], and higher proportions were misattributed to Instance 3 than Instance 4, $b = 0.12$ [0.04, 0.20], $t(24) = 3.05$, $p = .006$, $d = 0.76$ [0.24, 1.27]. There were two interactions between destination and study. As shown in the top left panel of Figure 5, the first interaction was for the contrast between Instances 2 and 3 and Studies 3 and 4 indicating the lack of a difference in the proportions of misattributions in Study 3, $b = 0.25$ [0.14, 0.34], $t(24) = 4.52$, $p < .001$, $d = 1.63$ [0.88, 2.37]. The second interaction indicated that the difference in the proportions of misattributions from Instance 1 reported in Instances 2 and 3 was more pronounced in Study 6 than in Study 5, $b = 0.35$ [0.15, 0.54], $t(24) = 3.69$, $p = .001$, $d = 2.23$ [2.13, 2.51]. There were no further significant contrasts or interactions after the correction for multiple tests (ps ≥ .046).

[INSERT FIGURE 5 HERE]

For details from Instance 4, higher proportions were misattributed to Instance 3 than Instance 2, $b = 0.18$ [0.10, 0.26], $t(24) = 4.67$, $p < .001$, $d = 0.78$ [0.44, 1.13], and higher proportions were misattributed to Instance 2 than Instance 1, $b = 0.28$ [0.23, 0.33], $t(24) = 11.89$, $p < .001$, $d = 1.22$ [1.01, 1.43]. There was one interaction between destination and recall session in the contrast between Instances 2 and 3 and Recall Sessions 3 and 4. As shown in the bottom right panel of Figure 6, the difference in the proportions of misattributions reported in Instances 2 and 3 was more pronounced in Recall Session 3 than Recall Session 4; $b = 0.16$ [0.05, 0.26], $t(24) = 3.00$, $p = .006$, $d = 0.67$ [0.21, 1.13]. There were also four interactions between destination and study. As shown in the bottom right panel of Figure 5, the first two interactions indicated differences in the proportions of misattributions reported in Instances 2 and 3 between Studies 1 and 2, $b = 0.40$ [0.16, 0.63], $t(24) = 3.52$, $p = .002$, $d = 1.71$ [0.71, 2.71], and between Studies 2 and 3, $b = 0.66$ [0.42, 0.89], $t(24) = 5.72$, $p < .001$, $d = 2.83$ [1.81, 3.85]. The next two interactions indicated that the difference in the proportions of misattributions reported in Instances 2 and 3 was more pronounced in Study 5 compared to Study 4, $b = 0.19$ [0.08, 0.29], $t(24) = 3.58$, $p = .002$, $d = 0.80$ [0.34, 1.27], and compared to Study 6, $b = 0.27$ [0.15, 0.40], $t(24) = 4.49$, $p < .001$, $d = 1.17$ [0.63, 1.71]. There were no further significant contrasts or interactions after the correction for multiple tests (ps $\geq .044$).

[INSERT FIGURE 6 HERE]

For details from Instance 2, higher proportions of misattributions were reported in Instance 3 compared to Instance 1, $b = 0.17$ [0.14, 0.21], $t(24) = 9.61$, $p < .001$, $d = 1.13$

[0.89, 1.37], and compared to Instance 4, $b = 0.29$ [0.25, 0.34], $t(24) = 13.52$, $p < .001$, $d =$ 1.91 [1.62, 2.20]. There were two interactions between destination and study. As shown in the top right panel of Figure 5, the interactions indicated differences in the proportions of misattributions reported in Instances 1 and 3 between Studies 1 and 2, $b = 0.46$ [0.28, 0.63], $t(24) = 5.44$, $p < .001$, $d = 2.98$ [1.85, 4.10], and between Studies 2 and 3, $b = 0.36$ [0.19, 0.53], $t(24) = 4.29$, $p < .001$, $d = 2.33$ [1.21, 3.45]. There were no further significant contrasts or interactions after the correction for multiple tests (ps $\geq .025$).

For details from Instance 3, higher proportions of misattributions were reported in Instance 2 compared to Instance 1, $b = 0.31$ [0.27, 0.35], $t(24) = 15.29$, $p < .001$, $d = 2.35$ [2.03, 2.67], and compared to Instance 4, $b = 0.09$ [0.06, 0.12], $t(24) = 5.66$, $p < .001$, $d =$ 0.68 [0.43, 0.93]. There were no further significant contrasts or interactions after the correction for multiple tests (ps $\geq .013$). An interaction between destination and recall session indicated that the difference in the proportions of misattributions reported in Instances 2 and 4 was more pronounced in Recall Session 3 than Recall Session 2 (see bottom left panel of Figure 6), $b = 0.08$ [0.02, 0.14], $t(24) = 2.67$, $p = .013$, $d = 0.59$ [0.13, 1.04]. There were also seven interactions between destination and study indicating differences in the patterns or their magnitudes across studies. The first two interactions indicated differences between Studies 1 and 2 in the proportions of misattributions reported in Instances 1 and 2, $b = 0.41$ [0.24, 0.59], $t(24) = 4.82$, $p < .001$, $d = 3.10$ [1.77, 4.43], and Instances 2 and 4 $b = 0.19$ [0.04, 0.35], $t(24) = 2.56$, $p = .017$, $d = 1.46$ [0.28, 2.64] (see the bottom left panel of Figure 5). The third interaction indicated a difference in the proportions of misattributions reported in Instances 1 and 2 between Studies 2 and 3, $b = 0.43$ [0.25, 0.61], $t(24) = 4.93$, $p < .001$, $d =$ 3.22 [1.87, 4.56]. The next three interactions indicated differences in the proportions of misattributions reported in Instances 2 and 4 between Studies 3 and 4, $b = 0.18$ [0.12, 0.24], $t(24) = 6.62$, $p < .001$, $d = 1.36$ [0.93, 1.78], Studies 4 and 5, $b = 0.33$ [0.27, 0.39], $t(24) =$

11.18, $p < .001$, $d = 2.46$ [2.00, 2.91], and Studies 5 and 6, $b = 0.24$ [0.17, 0.31], $t(24) = 7.22$, $p < .001$, $d = 1.82$ [1.30, 2.35]. The final interaction indicated that the difference in proportions of misattributions reported in Instances 1 and 2 was more pronounced in Study 5 compared to Study 4, $b = 0.22$ [0.12, 0.31], $t(24) = 4.70$, $p < .001$, $d = 1.64$ [0.92, 2.36]. There were no further significant contrasts or interactions after the correction for multiple tests (ps $\geq .022$).

To summarize, misattributions from all instances showed a gradual decrease correlating with the proximity of instances in which they were reported, and the patterns for misattributions from Instances 2 and 3 indicated an involvement of the primacy and recency effects. The patterns were overall consistent across recall sessions. Study interactions indicated that misattribution patterns in Study 2 differed from other studies, although the wide 95% Confidence Intervals of the mean proportions of misattributions showed high variability in the data rather than clearly inconsistent destination patterns. For misattributions from Instance 3 in Studies 1, 3, and 5, the lower proportions of misattributions reported in Instance 4 compared to Instance 3 are consistent with the (weak) recency effect, although this effect does not seem to be present in Studies 2, 4, and 6 (bottom left panel of Figure 5).

Discussion

This study is the first examination of trajectories of misattributions that frequently occur in recall of instances of repeated events. Overall, the patterns of misattributions confirmed the primacy and recency effects: The primacy effect generally limited misattributions from Instance 1 and the recency effect, in some cases, limited misattributions from Instance 4. The novel finding of the current analysis is the proximity effect: Participants most frequently misremembered details that originated from nearby instances, and most frequently misattributed details to instances that were nearer rather than further away from the source.

There were moderating effects of recall session typically indicating that the magnitudes of specific differences in misattribution proportions were more pronounced in the first than in the second recall session, but overall, the misattribution patterns remained consistent across recall sessions including delays of one month after stimuli presentation. The misattribution patterns were also highly consistent across Studies 1, 3, 4, 5, and 6, where heterogeneity was mainly in the magnitudes of differences in the proportions but not in the presence of the patterns.

Misattributions in Study 2 indicated few clear patterns. The two exceptions were: (i) for the sources of misattributions, a proximity effect indicating a greater proportion of misattribution from the adjacent Instance 3 reported in Instance 4; and (ii) for the destinations of misattributions, a proximity effect indicating a gradual decrease in proportions of misattributions from Instance 1 reported across Instances 2, 3, and 4. Importantly, although the misattribution patterns in Study 2 look different, Figures 3 and 5—especially the width of the 95% Confidence Intervals of the proportions—indicate that there was high variability in the data rather than clear inconsistencies. We would like to consider four reasons for the lack of clear patterns in Study 2. First, instance presentation was spaced across two weeks like in Study 1 but unlike in Studies 3 – 6. Spacing has been found to reduce overall reporting of misattributions (Price et al., 2006); however, there are no theoretical reasons why spacing should impact on the misattribution patterns.

Second, the stimuli in Study 2 were highly complex and more variable compared to the other studies. Consequently, there was an unequal number of unique details across instances (ranging between 10 – 15 details per instance), and some details had low variability (e.g., some details varied across two out of four instances; for further details, see Kontogianni et al., 2021). These differences could lead to unequal numbers of misattributions across instances.

Next, participants in Study 2 were not cued to instances and the recall instructions did not reveal the number of viewed videos. Indeed, 24% of participants described fewer or more than four instances. Cases where participants omitted whole instances would likely impact on the misattribution patterns (e.g., misattributions from one instance could be missing completely). This was, however, the case also in the other studies as participants sometimes did not provide any details for an instance or said they cannot remember that instance at all.

And finally, we only had data from one recall session in Study 2. Although misattributions in recall occur frequently, only a few details are reported by any given participant. Therefore, any analysis of trajectories of misattributions requires a large amount of data. It is possible that some of the patterns would become clearer if more data were available from Study 2, if for instance participants had been asked to recall events over more sessions.

Overall, we found highly consistent misattribution pattern across Studies 1 and 3 - 6 that employed variable methodologies (e.g., spacing of instances, stimuli), and at least some of these patterns were consistently present in Study 2. What do the misattribution patterns tell us about the organization of memory for repeated events?

Regularities in Misattributions in Recall of Instances of Repeated Events

The idea that people seek and create structure in their experiences has been the foundation of major theoretical approaches to memory phenomena at least since Bartlett proposed the concept of "effort after meaning" (1932; see also Mandler, 2002; 2011; Postman, 1971; Tulving, 1962; 1972). In the case of repeated events, most previous research has used the notion of the instance-level organization (i.e., scripts or schemata) to interpret the difficulty with correctly attributing details to instances (e.g., Hudson et al., 1992). Specifically, details of instances with a common theme within the schema (e.g., different grammatical problems covered at specific language classes) may be retained as part of the same category. Our examination of the trajectories of misattributions challenges this notion and suggests there is an additional level in the hierarchy: The organization of instances within a repeated event, which is likely encoded in the form of positional attributes of details.

Lee and Estes (1981) described this hierarchical organization in a learning task for items in a list.[2] Items are encoded along with information about their relative position in the higher-level structure (i.e., a list), where the relative position of items is defined by the boundaries (i.e., first/final items) and by links between adjacent items (see also Estes, 1985; Henson, 1998). In fact, already Ebbinghaus (1964) described that syllable sequences are encoded along with their positions in a sequence, and that associations are strongest for immediate neighbours and weaken with each intervening item. This process is consistent with Kahana's (1996, see also Lohnas et al., 2015; Polyn et al., 2009) context-based model of encoding and free recall, which assumes that items in a list are encoded along with inter-item associations, generating a context that is continuously updated with each new item. Johnson et al. (1993) described yet a similar process, where reflections on previous experiences (and other ongoing cognitive operations) may generate source attributes. The higher-level organization, learning context, or other form of source attributes retrieved along with an item then facilitate source monitoring during which a rememberer decides when a specific element occurred.

Errors in source memory arise because inter-item relationships are easily confusable, yet these confusions largely follow the order of the temporal organization of items (Lee & Estes, 1981). Specifically, the boundary items have fewer neighbours to get confused with, greater local distinctiveness (e.g., G. D. A. Brown et al., 2009), and naturally serve as anchors (e.g., Estes, 1985; Henson, 1998) contributing to the primacy and recency effects. Next, non-boundary items that occurred closer to each other get confused more easily than items that

[2] And for higher levels, such as lists in a sequence and sequences in a recall task (see Lee & Estes, 1981).

occurred further apart (Lee & Estes, 1981) generating the proximity effect. Although these models were originally proposed for short-term memory phenomena, a similar hierarchical structure has been described for long-term memory where first experiences (Robinson, 1992) or other transitional events (N. R. Brown, 2016) anchor long periods in autobiographical memory, and where error patterns follow temporal schemata and proximity gradients (e.g., Betz & Skowronski, 1997). It seems that memory for instances of repeated events is organized in a similar hierarchical structure, and that detail characteristics are linked with information about this structure, where primacy, recency, and proximity effects manifest as relatively predictable patterns of attribution errors.

To date, the main theoretical approaches that have been used in the investigation of memory for repeated events are schema/script theory (e.g., Bartlett, 1932; Schank & Abelson, 1975), fuzzy trace theory (Brainerd & Reyna, 2004), and the source monitoring framework (Johnson et al., 1993). The current results suggest that the source monitoring framework can be particularly useful to analyse data of memories of repeated events. When recall of multiple specific instances is assessed, which is likely to occur in applied settings (e.g., Kelloway et al., 2003; Stark, 2012), script and fuzzy trace theories only offer a generic explanation regarding memory errors, such as that misattributions are likely to occur due to the processes of memory organization following repeated experience and reconstructive recall. The source monitoring framework can integrate mechanisms that strengthen source memory for the boundary instances of repeated events and that contribute to the primacy and recency effects (i.e., the novelty of the first instance, and the unique encoding context and limited interference associated with the first and final instances; see Rubínová et al., In Press). Moreover, the source monitoring framework can accommodate the notion of positional attributes of details within the sequence of instances of repeated events as a consequence of the hierarchical structure of memory organization. Recall of instances of repeated events involves strategic processes where decisions about recalled information are made on the basis of attributes of specific details, and we believe that the source monitoring framework is best suited to shed light on the specific aspects of memory errors. Future research could rely further on the use of the source monitoring approach and conduct (re)analyses of repeated event memories in increased depth by investigating patterns that arise from free recall.

Limitations

The main limitation of this research is the number of instances administered in the repeated events under investigation. Four instances allowed for the proximity effects to be observed but did not allow for any differentiation between proximity and primacy and recency effects for details from the boundary instances (although we still observed the proximity effects in misattribution patterns of the middle instances). It is possible that such differentiation would be possible with a higher number of instances. Specifically, it is not clear whether the proximity effect is only relevant for the adjacent instances and then it levels off, or whether it is continuous, because the primacy or recency effects were always potentially in place after two following instances (i.e., the greatest distance in our studies). With a higher number of instances, a continuous decrease in the proportion of confusions with increasing distance across instances could indicate a proximity effect that would be based on the reflection of relations across multiple instances. By contrast, a decrease that would level off after a couple of instances would indicate that the proximity effect mainly reflects relations across a few nearby instances.

Conclusion

Memory for repeated events is typically described as a script associated with details that occurred during various instances. Our findings show that these details are not isolated items; rather, details contain attributes that can be used to make systematic decisions regarding the details' source instance. These attributes rarely provide tags to source instances but are rather represented as organized relations among instances. Although confusions easily occur within this organization, there is a method to the pattern of misattributions that reflects the relative position of instances anchored by the boundary instances. The primacy, recency, and proximity effects associated with this higher-level structure then manifest as predictable source attribution errors. In other words, people less frequently confuse details of the boundary instances and more frequently confuse details of adjacent instances.

Declarations

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Conflicts of Interest

The authors declare no conflict of interests.

Ethics Approval

All studies were approved by the Science Faculty Ethics Committee at the University of Portsmouth. Reference codes: SFEC 2018-014 (Study 1), SFEC 2016-036 (Study 2), and SFEC 2014-010 (Studies 3, 4, 5, and 6).

Consent to Participate

Participants in all studies provided written consent to participate.

Consent for Publication

The informed consent that participants provided included information about the intention to publish the research.

Availability of Data, Materials, and Code

Data for all studies along with a code-book, coding function scripts and the data analysis scripts are available as Online Supplemental Materials at Open Science Framework at [https://osf.io/9gsy4/?view_only=261c285c89ac4c1db4edf6ab033fbfb7]. Statistical analyses accompanying observations described in the manuscript are also available there.

Authors' Contribution

Eva Rubínová and Feni Kontogianni developed the study concept. Eva Rubínová developed the analysis plan, conducted the analyses, interpreted the data, and drafted the manuscript and supplemental materials. Feni Kontogianni provided critical feedback on the manuscript.

Open Practices Statement

None of the studies reported in this article was formally preregistered for the purpose of the current study. Data for all studies along with a code-book, coding function scripts and the data analysis scripts are available as Online Supplemental Materials at Open Science Framework at [https://osf.io/9gsy4/?view_only=261c285c89ac4c1db4edf6ab033fbfb7]. Statistical analyses accompanying observations described in the manuscript are also available there.

References

Ahn, W. K., Brewer, W. F., & Mooney, R. J. (1992). Schema acquisition from a single example. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18*, 391-412. https://doi.org/10.1037/0278-7393.18.2.391

Bartlett, F. C. (1932). *Remembering: A study in experimental and social psychology*. Cambridge, UK: Cambridge University.

Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: a practical and powerful approach to multiple testing. *Journal of the Royal statistical society: Series B (Methodological), 57*, 289-300. https://doi.org/10.1111/j.2517-6161.1995.tb02031.x

Ben-Shachar, M., Lüdecke, D., & Makowski, D. (2020). effectsize: Estimation of Effect Size Indices and Standardized Parameters. *Journal of Open Source Software, 5*, 2815. doi: 10.21105/joss.02815

Betz, A. L., & Skowronski, J. J. (1997). Self-events and other-events: Temporal dating and event memory. *Memory & Cognition, 25*, 701-714. https://doi.org/10.3758/BF03211313

Bjork, E. L., & Healy, A. F. (1974). Short-term order and item retention. *Journal of Verbal Learning and Verbal Behavior*, *13*, 80-97. https://doi.org/10.1016/S0022-5371(74)80033-2

Brainerd, C. J., & Reyna, V. F. (2004). Fuzzy-trace theory and memory development. *Developmental Review, 24*, 396-439. https://doi.org/10.1016/j.dr.2004.08.005

Brown, G. D. A., Vousden, J. I., & McCormack, T. (2009). Memory retrieval as temporal discrimination. *Journal of Memory and Language*, *60*, 194-208.

Brown, N. R. (2016). Transition theory: A minimalist perspective on the organization of autobiographical memory. *Journal of Applied Research in Memory and Cognition, 5*, 128-134. https://doi.org/10.1016/j.jarmac.2016.03.005

Canty, A., & Ripley, B. D. (2021). *Boot: Bootstrap R (S-Plus) Functions*. R package version 1.3-26.

Chang, W. (2014). *extrafont: Tools for using fonts*. R package version 0.17. https://CRAN.R-project.org/package=extrafont

Cumming, G. (2012). *Understanding the new statistics: Effect sizes, confidence intervals, and meta-analysis*. Hove, UK: Routledge.

Cumming, G. (2014). The new statistics why and how. *Psychological Science*, *25*, 7-29. https://doi.org/10.1177/0956797613504966

Deck, S. L., & Paterson, H. M. (2021). Adults also have difficulty recalling one instance of a repeated event. *Applied Cognitive Psychology*, *35*, 286-292. https://doi.org/10.1002/acp.3736

Dilevski, N., Paterson, H. M., & van Golde, C. (2020a). Investigating the impact of stress on adult memory for single and repeated events. *Psychology, Public Policy, and Law*. https://doi.org/ 10.1037/law0000248

Dilevski, N., Paterson, H. M., & van Golde, C. (2020b). Adult memory for instances of a repeated emotionally stressful event: Does retention interval matter? *Memory*. https://doi.org/10.1080/09658211.2020.1860227

Ebbinghaus, H. (1964). *Memory: A contribution to experimental psychology*. (H. A. Ruber and C. E. Bussenius, Trans.). New York, NY: Dover Publications, Inc.

Estes, W. K. (1985). Memory for temporal information. In J. A. Michon & J. L. Jackson (Eds.), *Time, mind, and behavior* (pp. 151-168). Berlin, GE: Springer.

Farrar, M. J., & Boyer-Pennington, M. E. (1999). Remembering specific episodes of a scripted event. *Journal of Experimental Child Psychology, 73*, 266-288. https://doi.org/10.1006/jecp.1999.2507

Farrar, M. J., & Goodman, G. S. (1990). Developmental differences in the relation between scripts and episodic memory: Do they exist? In R. Fivush & J. Hudson (Eds.), *Knowing and remembering in young children* (pp. 30-64). New York, NY: Cambridge University Press.

Hard, B. M., Tversky, B., & Lang, D. S. (2006). Making sense of abstract events: Building event schemas. *Memory & Cognition, 34*, 1221-1235. https://doi.org/10.3758/BF03193267

Healy, A. F. (1974). Separating item from order information in short-term memory. *Journal of Verbal Learning and Verbal Behavior*, *13*, 644-655. https://doi.org/10.1016/S0022-5371(74)80052-6

Henson, R. N. (1998). Short-term memory for serial order: The start-end model. *Cognitive Psychology, 36*, 73-137. https://doi.org/10.1006/cogp.1998.0685

Hudson, J. A., Fivush, R., & Kuebli, J. (1992). Scripts and episodes: The development of event memory. *Applied Cognitive Psychology, 6*, 483-505. https://doi.org/10.1002/acp.2350060604

Hudson, J. A., & Mayhew, E. M. Y. (2008). The development of memory for recurring events. In M. Courage and N. Cowan (Eds.), *The Development of Memory in Infancy and Childhood: Second Edition* (pp. 69-91). Psychology Press Taylor & Francis Group.

James, W. (1901). *Principles of psychology* (Vol. 1). London, UK: Macmillan.

Johnson, M. K., Hashtroudi, S., & Lindsay, D. S. (1993). Source monitoring. *Psychological Bulletin, 114*, 3-28. https://doi.org/10.1037/0033-2909.114.1.3

Kahana, M. J. (1996). Associative retrieval processes in free recall. *Memory & Cognition, 24*, 103-109. https://doi.org/10.3758/BF03197276

Kelloway, E. K., Stinson, V., & MacLean, C. (2004). Eyewitness testimony in occupational accident investigations: Towards a research agenda. *Law and Human Behavior, 28*, 115-132. https://doi.org/10.1023/B:LAHU.0000015006.67141.44

Kontogianni, F., Rubinova, E., Hope, L., Taylor, P. J., Vrij, A., & Gabbert, F. (2021). Facilitating recall and particularisation of repeated events in adults using a multi-method interviewing format. *Memory*. https://doi.org/10.1080/09658211.2021.1903508

Larsen, S. F., & Thompson, C. P. (1995). Reconstructive memory in the dating of personal and public news events. *Memory & Cognition, 23*, 780-790. https://doi.org/10.3758/BF03200929

Lee, C. L., & Estes, W. K. (1977). Order and position in primary memory for letter strings. *Journal of Verbal Learning and Verbal Behavior, 16*, 395-418. https://doi.org/10.1016/S0022-5371(77)80036-4

Lee, C. L., & Estes, W. K. (1981). Item and order information in short-term memory: Evidence for multilevel perturbation processes. *Journal of Experimental Psychology: Human Learning and Memory*, *7*, 149-169. https://doi.org/10.1037/0278-7393.7.3.149

Lindsay, D. S. (2008). Source Monitoring. In H. L. Roediger, III (Ed.), *Cognitive Psychology of Memory: Vol. 2.* J. Byrne (Ed.), *Learning and Memory: A Comprehensive Reference* (pp. 325-348). Oxford: Elsevier.

Lindsay, D. S. (2014). Memory Source Monitoring Applied. In T. J. Perfect & D. S. Lindsay (Eds.), *The SAGE Handbook of Applied Memory* (pp 59-75). London: SAGE.

Loftus, E. F., & Marburger, W. (1983). Since the eruption of Mt. St. Helens, has anyone beaten you up? Improving the accuracy of retrospective reports with landmark events. *Memory & Cognition, 11*, 114-120. https://doi.org/10.3758/BF03213465

Lohnas, L. J., Polyn, S. M., & Kahana, M. J. (2015). Expanding the scope of memory search: Modeling intralist and interlist effects in free recall. *Psychological Review, 122*, 337-363. https://doi.org/10.1037/a0039036

MacLean, C. L., Coburn, P. I., Chong, K., Connolly, D. L. (2018). Breaking script: Deviations and postevent information in adult memory for a repeated event. *Applied Cognitive Psychology, 32*, 474- 486. https://doi.org/10.1002/acp.3421

Mandler, G. (2002). Organisation: What levels of processing are levels of. *Memory*, *10*, 333-338. https://doi.org/10.1080/09658210244000153

Mandler, G. (2011). From association to organization. *Current directions in Psychological Science, 20*, 232-235. https://doi.org/10.1177/0963721411414656

Nørby, S. (2015). Why forget? On the adaptive value of memory loss. *Perspectives on Psychological Science*, *10*, 551-578. https://doi.org/10.1177/1745691615596787

Polyn, S. M., Norman, K. A., & Kahana, M. J. (2009). Task context and organization in free recall. *Neuropsychologia*, *47*, 2158-2163. https://doi.org/10.1016/j.neuropsychologia.2009.02.013

Postman, L. (1971). Organisation and interference. *Psychological Review, 78*, 290-302. https://doi.org/10.1037/h0031031

R Core Team. (2020). *R: A language and environment for statistical computing.* R Foundation for Statistical Computing, Vienna, Austria. Retrieved from https://www.R-project.org/.

Revelle, W. (2020). *psych: Procedures for Personality and Psychological Research*, Northwestern University, Evanston, Illinois, USA, https://CRAN.R-project.org/package=psych Version = 2.0.9.

Robinson, J. A. (1992). First experience memories: Contexts and functions in personal histories. In M. A. Conway, D. C. Rubin, H. Spinnler, & W. A. Wagenaar (Eds.), *Theoretical perspectives on autobiographical memory* (pp. 223-239). Dordrecht, NL: Springer.

Rubin, D. C., & Baddeley, A. D. (1989). Telescoping is not time compression: A model. *Memory & Cognition, 17*, 653-661. https://doi.org/10.3758/BF03202626

Rubínová, E. (2020a). Appendix B. Disabling rehearsal in a repeated event paradigm disabled schema establishment and nullified deviation effects. In *Schema and deviation effects in adults' memory for repeated events* [Doctoral dissertation] (pp. 118-126). https://researchportal.port.ac.uk/portal/en/theses/schema-and-deviation-effects-in-adults-memory-for-repeated-events(cb6e11d0-28f5-45a5-97c8-641225fcafe8).html

Rubínová, E. (2020b). Chapter 4. Adults' memory for instances of a self-experienced interactive repeated event. In *Schema and deviation effects in adults' memory for repeated events* [Doctoral dissertation] (pp. 82-102). https://researchportal.port.ac.uk/portal/en/theses/schema-and-deviation-effects-in-adults-memory-for-repeated-events(cb6e11d0-28f5-45a5-97c8-641225fcafe8).html

Rubínová, E., Blank, H., Koppel, J., Dufková, E., & Ost, J. (In Press). Repeated recall of repeated events: Accuracy and Consistency. Manuscript accepted for publication in the *Journal of Applied Research in Memory and Cognition.* https://doi.org/10.1016/j.jarmac.2021.09.003

Rubínová, E., Blank, H., Koppel, J., & Ost, J. (2021). Schema and deviation effects in remembering repeated unfamiliar stories. *British Journal of Psychology, 112*, 180-206. https://doi.org/10.1111/bjop.12449

Rubínová, E., Blank, H., Ost, J., & Fitzgerald, R. J. (2020). Structured word-lists as a model of basic schemata: deviations from content and order in a repeated event paradigm, *Memory*, *28*, 309-322. https://doi.org/10.1080/09658211.2020.1712421

Rumelhart, D. E., Smolensky, P., McClelland, J. L., & Hinton, G. (1986). Schemata and sequential thought processes in PDP models. In J. L. McClelland, D. E. Rumelhart and the PDP Research Group (Eds.), *Parallel Distributed Processing: Explorations in the microstructures of cognition* (pp. 3-57). Cambridge, MA: MIT.

Schad, D. J., Vasishth, S., Hohenstein, S., & Kliegl, R. (2020). How to capitalize on a priori contrasts in linear (mixed) models: A tutorial. *Journal of Memory and Language*, *110*. https://doi.org/10.1016/j.jml.2019.104038

Schank, R. C. (1999). *Dynamic memory revisited*. Cambridge, UK: Cambridge University Press.

Schank, R. C. & Abelson, R. P. (1975). *Scripts, plans, and knowledge*. In Proceedings of the 4th International Joint Conference on Artificial Intelligence - Volume 1 (pp. 151–157). San Francisco, CA, USA: Morgan Kaufmann Publishers Inc. Retrieved from http://dl.acm.org/citation.cfm?id=1624626.1624649

Shum, M. S. (1998). The role of temporal landmarks in autobiographical memory processes. *Psychological Bulletin, 124*, 423-442. https://doi.org/10.1037/0033-2909.124.3.423

Slackman, E., & Nelson, K. (1984). Acquisition of an unfamiliar script in story form by young children. *Child Development*, 329-340. https://doi.org/10.2307/1129946

Stark, E., 2012. Looking beyond domestic violence: Policing coercive control. *Journal of Police Crisis Negotiations*, *12*, 199–217. https://doi.org/10.1080/15332586.2012.725016

Thompson, C. P., Skowronski, J. J., & Betz, A. L. (1993). The use of partial temporal information in dating personal events. *Memory & Cognition, 21*, 352-360. https://doi.org/10.3758/BF03208267

Tulving, E. (1962). Subjective organisation in free recall of “unrelated” words. *Psychological Review, 69*, 344-354. https://doi.org/10.1037/h0043150

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Donaldson (Eds.), *Organization of memory* (pp. 381-403). London, UK: Academic Press.

van Kesteren, M. T. R., Beul, S. F., Takashima, A., Henson, R. N., Ruiter, D. J., & Fernández, G. (2013). Differential roles for medial prefrontal and medial temporal cortices in schema-dependent encoding: from congruent to incongruent. *Neuropsychologia, 51*, 2352-2359. https://doi.org/10.1016/j.neuropsychologia.2013.05.027

Venables, W. N., & Ripley, B. D. (2002). *Modern Applied Statistics with S*, Fourth edition. Springer, New York. ISBN 0-387-95457-0. http://www.stats.ox.ac.uk/pub/MASS4/

Wickham, H. (2016). *ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag New York. ISBN 978-3-319-24277-4. https://ggplot2.tidyverse.org

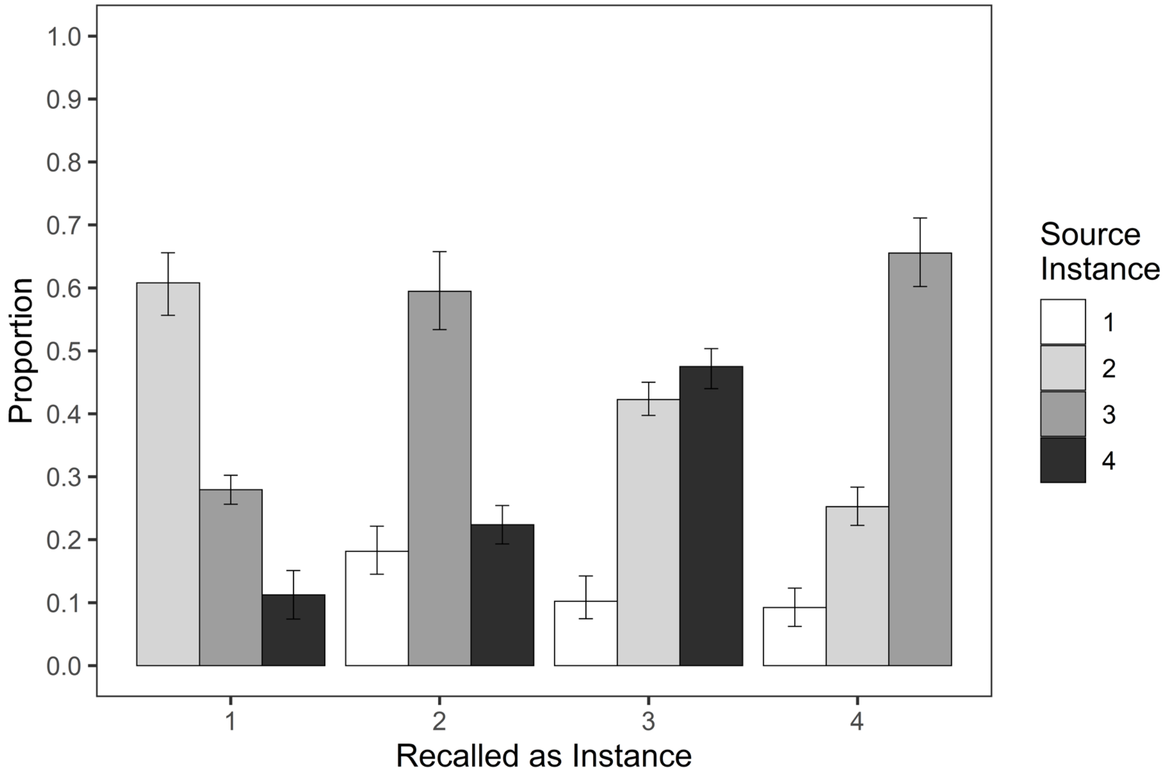
Wickham, H. (2007). Reshaping Data with the reshape Package. *Journal of Statistical Software, 21*, 1-20. URL http://www.jstatsoft.org/v21/i12/.

Wickham, H., François, R., Henry, l., & Müller, K. (2020). *dplyr: A Grammar of Data Manipulation*. R package version 1.0.2. https://CRAN.R-project.org/package=dplyr

Woiwod, D. M., Fitzgerald, R. J., Sheahan, C. L., Price, H. L., & Connolly, D. A. (2019). A meta-analysis of differences in children's reports of single and repeated events. *Law and Human Behavior, 43*, 99-116. https://doi.org/10.1037/lhb0000312

Figure 1

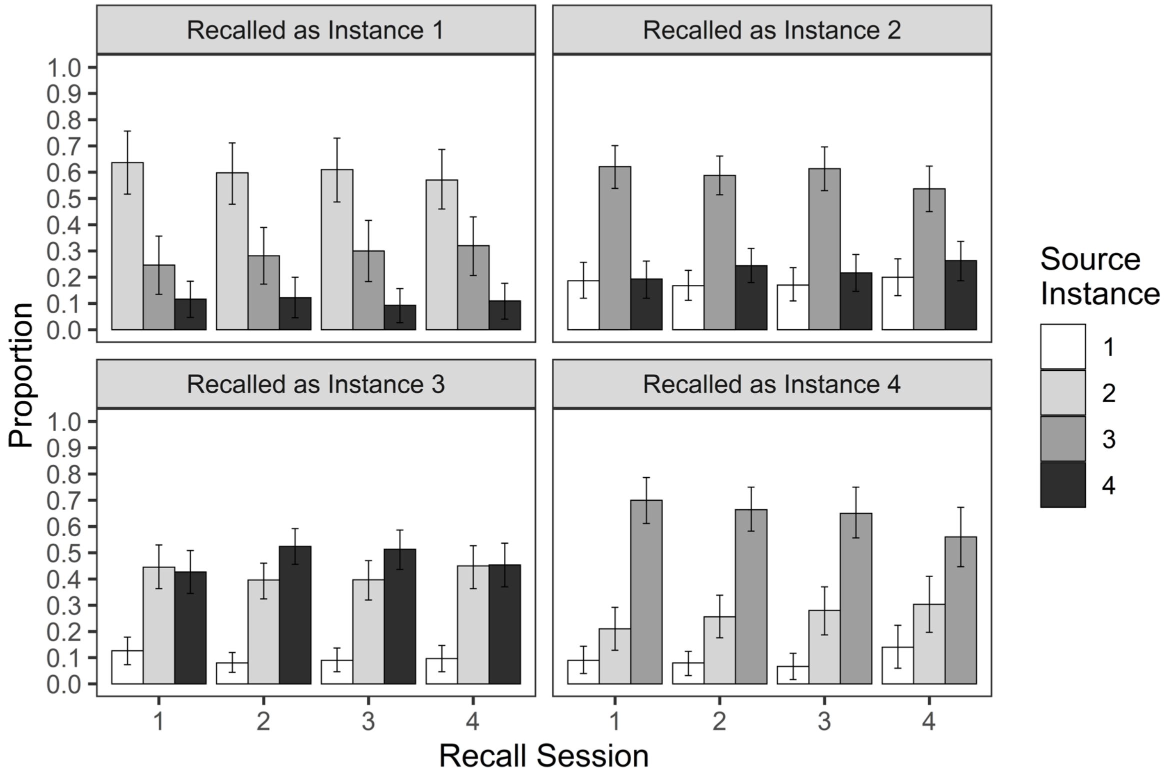
Sources of misattributions



Note. Data were averaged across studies and multiple recall sessions. Error bars represent bootstrapped 95% Confidence Intervals of the means.

Figure 2

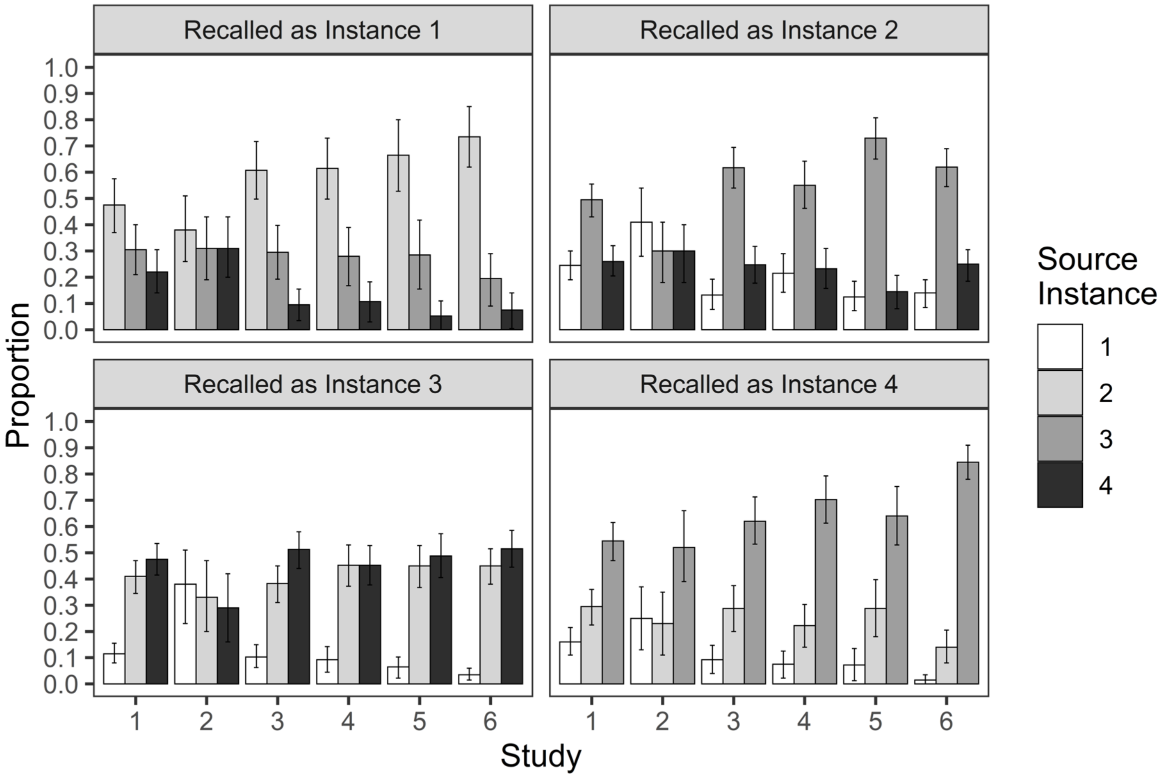
Sources of misattributions in recall of instances across recall sessions



Note. Data were averaged across studies. Error bars represent bootstrapped 95% Confidence Intervals of the means.

Figure 3

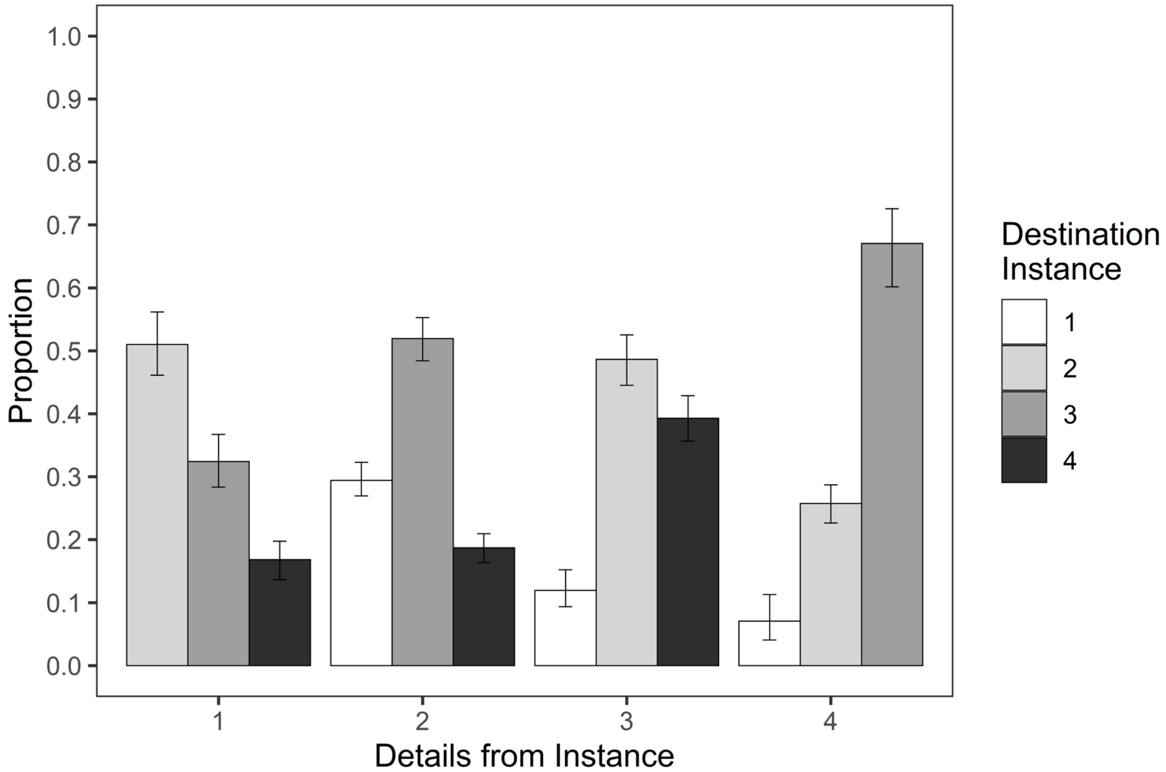
Sources of misattributions in recall of instances across studies



Note. Data were averaged across multiple recall sessions in Studies 1, 3, 4, 5, and 6. Error bars represent bootstrapped 95% Confidence Intervals of the means.

Figure 4

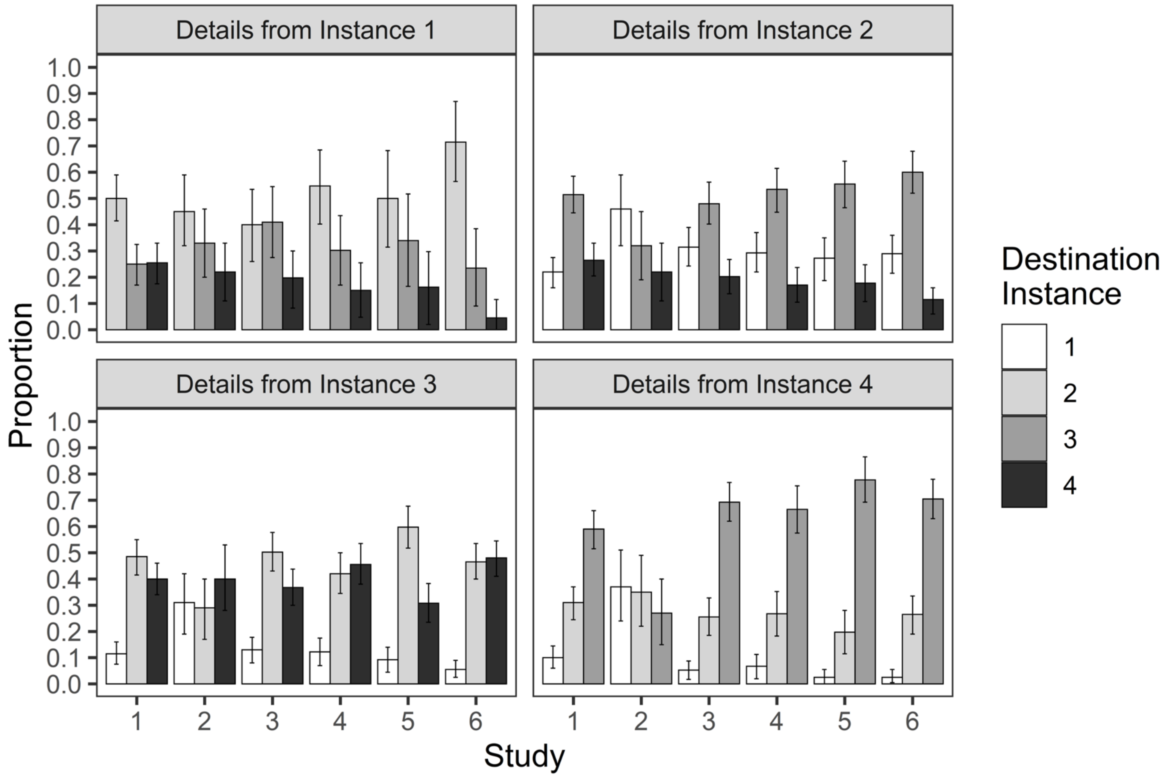
Destinations of misattributions



Note. Data were averaged across studies and multiple recall sessions. Error bars represent bootstrapped 95% Confidence Intervals of the means.

Figure 5

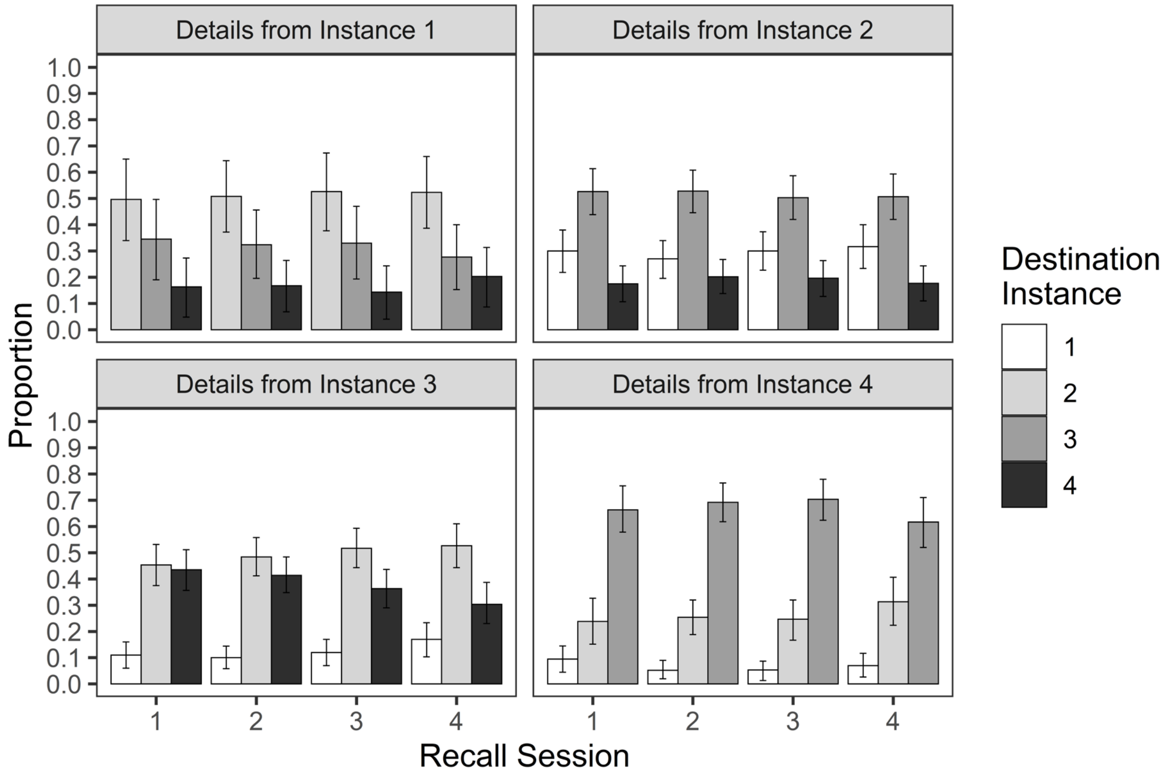
Destinations of misattributions in recall of instances across studies



Note. Data were averaged across multiple recall sessions in Studies 1, 3, 4, 5, and 6. Error bars represent bootstrapped 95% Confidence Intervals of the means.

Figure 6

Destinations of misattributions in recall of instances across recall sessions



Note. Data were averaged across studies. Error bars represent bootstrapped 95% Confidence Intervals of the means.