Memory for Missing Parts of Witnessed Events

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ABSTRACT. This study examined how children and adults fill in missing parts of witnessed events. In 2 experiments, children and adults studied 6 series of PowerPoint slides that each depicted a single event. At test in Experiment 1, participants viewed old slides, new slides, and slides that had been missing from studied events. Both children and adults falsely recognized missing slides more than new slides: $F(1, 104) = 162.97$, $p < .001$, $\eta_p^2 = .61$ for children, and $F(1, 104) = 497.23$, $p < .001$, $\eta_p^2 = .83$ for adults. These results suggest that participants filled in the missing parts of witnessed events. However, an alternative explanation is that children falsely recognized missing slides because the missing slides superficially resembled the studied slides. At test in Experiment 2, participants viewed old slides, new slides, and slides that contained the same items as studied slides but with the items rearranged in the slides so they were incongruent with studied slides. Both children and adults recognized old slides more than incongruent slides: $F(1, 90) = 16.86$, $p < .001$, $\eta_p^2 = .16$ for children, and $F(1, 90) = 215.20$, $p < .001$, $\eta_p^2 = .70$ for adults. This undermined the alternative explanation, thereby supporting the original explanation that the false recognition of missing slides in Experiment 1 is attributable to the filling in of missing information.

When there is one witness to a crime, the testimony from that individual could be the crucial piece of evidence that brings the perpetrator to justice (Brackmann, Otgaar, Sauerland, & Jelicic, 2016; Roberts & Powell, 2001). Of course, the testimony is only as reliable as the witness's memory, which is notoriously susceptible to the creation of false memories (Gleaves, Smith, Butler, & Spiegel, 2004). The formation of false memories is particularly relevant when the witness is a child because children cannot as easily distinguish between fantasy and reality as adults (Brainerd, Reyna, & Forrest, 2002). Indeed, the bulk of evidence has shown that the formation of false memories declines with age, from about three years of age to young adulthood (Brainerd, Reyna, & Ceci, 2008; Otgaar, Howe, Brackmann, & Smeets, 2016). One glaring exception to this developmental trend is associated with the well-known Deese (1959), and Roediger and McDermott (1995) paradigm, which is generally known by its abbreviation: DRM. In fact, the general decrease in false memories with age is such a well-established pattern that the increase of false memories in the DRM with age has been called a developmental reversal (Otgaar & Smeets, 2010).

In the typical DRM experiment (reviewed in Gallo, 2010), participants study several lists of associated words such as *sugar, sour, cake, ice cream,* and so on, but do not study the word they are all associated with, which in this case is *sweet*. During the test, participants view words they studied (old), words unrelated to studied words (new), and nonstudied associated words (missing), and are asked whether they had seen those words in the study phase. Participants are likelier to falsely recognize missing words than new words; apparently, participants do not store a verbatim copy of studied words in memory, but instead extract and store the gist of the studied words (Gallo, 2010).

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A review of developmental studies of the DRM (Brainerd et al., 2008) found that false recognition of missing words increases with age: between the ages of three and the early 20s, false recognition doubles. Children's semantic networks are underdeveloped compared to adults (Fisher, Godwin, Matlen, & Unger, 2015), so they are less able to notice semantic connections between words. One objection to these results is that the words used in DRM experiments were normed for adults, so perhaps children fail to appreciate the semantic connections between words because they have different semantic networks than adults. However, studies in which experimenters carefully developed word lists normed for children (Anastasi & Rhodes, 2008; Metzger et al., 2008) found the same pattern in which false memories for missing words increased with age.

Although children's grasp of semantic similarity between words is less developed than adults, children may retain more details in memory than they can express in words (Uehara, 2015). In a classic study (Heider & Simmel, 1944), adult participants viewed a short film that began with a triangle and circle spinning around each other, then after a moment a large triangle entered the scene, which bumped and pushed the small triangle off the screen. The circle entered a square structure, followed by the large triangle, then a "door" to the square closed. The small triangle reentered the scene, pried open the door for the circle to escape, then slammed the door, trapping the large triangle inside. The film ended with the circle and small triangle once again spinning around each other. When asked to describe the film, viewers did not merely say that three shapes were moving randomly, but instead described a love story, chase, and escape. In a later study (Berry & Springer, 1993), children aged 3, 4, and 5 years old who viewed the same video were just as able as adults to describe the film as a simple story involving three characters. This suggests that, although children are less likely than adults to extract semantic relations between words, they are equally likely to extract semantic details from simple events. Indeed, when young children (5 and 6 years old) and older children (between 10 and 12 years old) experienced a themed event, both younger and older children were better able to recall details consistent with the theme than generic details (Odegard, Cooper, Lampinen, Reyna, & Brainerd, 2009). This suggests that both younger and older children can extract the gist from their prior experiences.

Combining elements of the DRM and event perception, the present study investigated how children perceive and remember events, some of which have missing pieces. When viewing events in the real world, some parts of the events may be hidden from view. For example, while watching a football game at the stadium, a spectator may see the quarterback throw the football, but while the ball is in the air, the person seated directly ahead stands up, hiding the path of the ball from the spectator's view. Fortunately, the man steps into the aisle quickly enough that the spectator can see the receiver catch the ball. If the spectator were to extract the gist of the event from the parts that were visible to her, would she later recall the ball flying through the air even though she had not actually seen that part of the play? Because both younger and older children extract gist from experienced events (Odegard et al., 2009), we hypothesized that both younger children and adults would fill in missing parts of witnessed events from the global gist of witnessed events. To test this hypothesis, for Experiment 1, we created several groups of PowerPoint slides that each depicted a single event. For some events, we showed all the slides to participants, and for other events, we removed one of the slides from the event. After participants viewed the events, we showed them (a) slides from events they had witnessed in their entirety (old slides), (b) slides that had been removed from witnessed events (missing slides), and (c) slides from events they had not seen at all (new slides). If the children and adults filled in missing pieces of witnessed events as we hypothesized, we expected that they would recognize old and missing slides but not new slides.
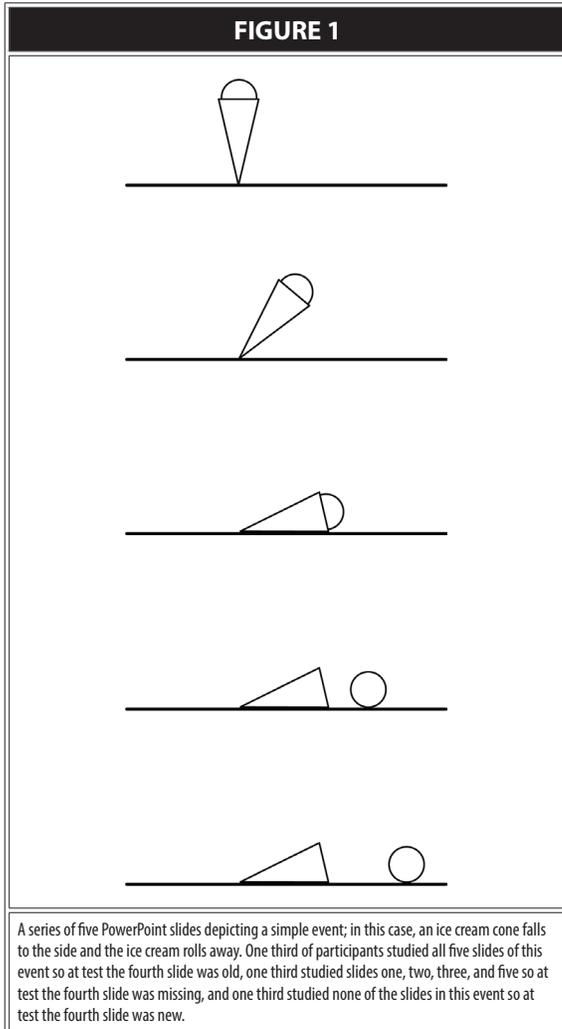
Experiment 1
Memory for Missing Slides

Method

Participants. We obtained permission from the Institutional Review Board at the University of Central Arkansas (UCA) to carry out both experiments and treated participants in accordance with the ethical guidelines stipulated by the American Psychological Association (2010). The title of our IRB proposal was Event Perception and False Memories, proposal number 15-198. Child participants were 17 preschool children (10 girls, 7 boys) between the ages of 4 years, 2 months, and 5 years, 4 months (M = 4 years, 8 months, SD = 5 months) who attend the UCA Child Study Center. To compare the results of the children to adults, we drew

A series of five PowerPoint slides depicting a simple event; in this case, an ice cream cone falls to the side and the ice cream rolls away. One third of participants studied all five slides of this event so at test the fourth slide was old, one third studied slides one, two, three, and five so at test the fourth slide was missing, and one third studied none of the slides in this event so at test the fourth slide was new.

FIGURE 2

Mean number of "yes" responses from Experiment 1. Error bars represent standard error of the mean.

a sample of 37 undergraduate students (33 women, 4 men) between the ages of 18 and 35 ($M = 21.41$, $SD = 2.80$). Students enrolled in psychology courses were able to receive credit from their instructors for participating in the experiment.

Materials. We created six groups of five slides in PowerPoint that each depict a simple event, an example of which is shown in Figure 1. All study and test slides were presented on a computer. Participants viewed two of the events in their entirety, two events with the fourth slide removed, and did not view the other two events at all. The events were counterbalanced across participants so the event viewed in its entirety by one third of participants was the event with a missing slide for another third of participants, and was the unseen event for the final third of participants. The presentation order of study and test slides was also counterbalanced across participants. Responses were recorded on data entry sheets that we created in Microsoft Word.

Procedure. Any child whose parents signed an informed consent form was eligible to participate in the experiment. To obtain verbal assent, the experimenter introduced herself to each child by saying "I would like to show you some events on a computer, then I'll show you some pictures on the computer and ask if you had seen the pictures before. Does that sound like something you would like to do today?" Undergraduate students were given an informed consent form. After obtaining verbal assent (from children) or informed consent (from undergraduate students), the experimenter clicked the mouse on the computer to begin a PowerPoint slideshow.

Participants studied four events consisting of slides presented in order. PowerPoint's animation tool successively presented each study slide for one second. Then, after each set of slides constituting a single event, a blank slide appeared and remained on the computer screen. While the blank slide was visible the experimenter asked "Are you ready to view the next event?" After receiving verbal confirmation, she clicked the mouse to launch the next event. After the study phase, participants viewed the fourth slide from all six events, one at a time. The experimenter clicked the mouse to present a test slide, then after it appeared, she asked "Did you see this slide before?" Each test slide remained continually visible until participants provided a verbal response. For any participants who gave any response other than "yes" or "no" such as "I don't know," the experimenter gently urged the participant by saying "Which answer feels right, yes
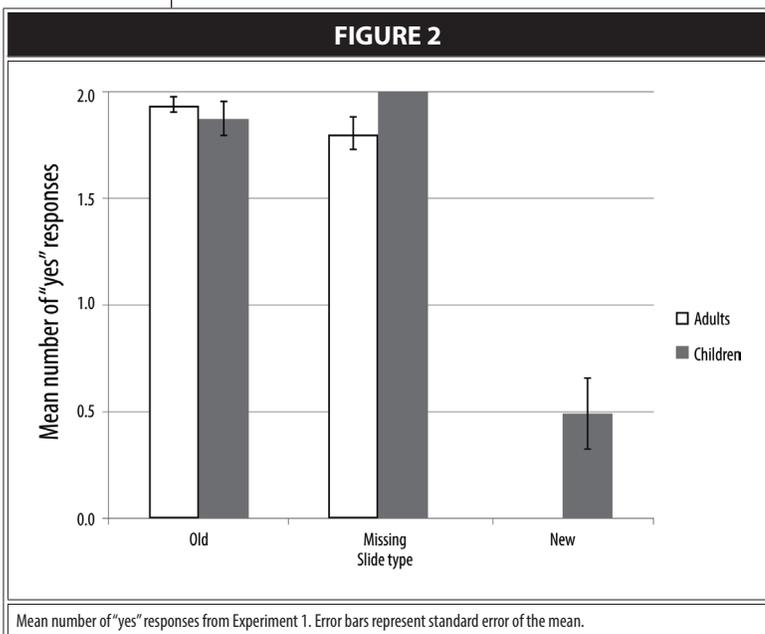
or no?" For each event, the experimenter used a pen to record each response by circling either "Y" or "N" on a datasheet that had been printed with six numbered sets of Ys and Ns for each participant. The experimenter then clicked the mouse to present the next test slide.

Results

The independent variables were age (child or adult) and slide type (old, missing, or new). The dependent variable was the number of "yes" responses to the question "Did you see this slide during the study phase?" Because each participant viewed two old, two missing, and two new slides in the test phase, there were zero, one, or two "yes" responses for each participant and slide type. The mean numbers of "yes" responses from children and adults (depicted in Figure 2) were submitted to a 2 x 3 Analysis of Variance (ANOVA) with age as a between-subjects variable and slide type as a within-subjects variable. The main effect of age was significant, $F(1, 52) = 10.40$, $p = .002$, $\eta_p^2 = .17$, indicating that children were likelier than adults to respond "yes," perhaps because they wanted to be agreeable to the experimenter (Brackmann et al., 2016). The main effect of slide type was significant, $F(2, 104) = 357.46$, $p < .001$, $\eta_p^2 = .87$. To test our hypothesis that both children and adults would recognize old and missing slides but not new slides, we planned to calculate contrasts between old and missing slides, and between missing and new slides for children and adults. The results from the planned contrasts showed that, for both children and adults, the difference between old and missing slides was not significant, both $ps > .09$, but the difference between missing and new slides was significant: $F(1, 104) = 162.97$, $p < .001$, $\eta_p^2 = .61$ for children, and $F(1, 104) = 497.23$, $p < .001$, $\eta_p^2 = .83$ for adults. The age x slide type interaction was significant, $F(2, 104) = 6.82$, $p = .002$, $\eta_p^2 = .12$, indicating that the difference between children and adults varied across slide type. We carried out simple effects analyses to further investigate this interaction. The differences between children and adults were not significant for either old or missing slides, both $Fs < 1$, but children were significantly likelier to say "yes" to new slides than adults, $F(1, 52) = 4.33$, $p = .040$, $\eta_p^2 = .077$.

Discussion

The significant difference between children and adults for new slides but not old or missing slides suggests that the main effect of age was driven primarily by children being likelier to respond "yes" to new slides. Nevertheless, although children were likelier to respond "yes" to new slides than adults, children could still distinguish between the missing and new slides, as indicated by the results from the planned contrasts. Indeed, the results from these planned contrasts, in which both adults and children were likelier to respond "yes" to missing slides than new slides, supported our hypothesis that both children and adults fill in missing parts of witnessed events. However, an alternative explanation is that children recognized missing slides, not because the missing slides fit into a witnessed event, but because the items on missing slides are the same items as in studied slides; for the event in Figure 1, children might have recognized the circle and triangle. After all, for word lists, children are likelier than adults to falsely recognize nonstudied words that rhyme with studied words (i.e., they are superficially related to studied words; Brainerd et al., 2002). In Experiment 1, missing slides presented at test were related both semantically and superficially to studied slides, so a limitation of Experiment 1 was that there is no way to distinguish between the two explanations.

In Experiment 2, instead of using test slides that were missing from studied events, participants viewed test slides that contained all the same items as studied slides, but the items were rearranged so that they were incongruent with the witnessed event. Although children are likelier than adults to falsely recognize rhyming words, children's comprehension of simple events is similar to adults (Berry & Springer, 1993). With that in mind, we hypothesized that both children and adults would recognize old slides but not incongruent slides.

Experiment 2
Memory for Incongruent Slides

Method

Participants and Materials. Participants were the same as in Experiment 1. However, because of a technical problem, seven of the adults from Experiment 1 did not participate in Experiment 2, so just 30 adults (26 women, 4 men) between the ages of 18 and 35 ($M = 21.43$, $SD = 3.11$) participated in Experiment 2. We created six new events, and an incongruent test slide for each event. Incongruent test slides contained the same shapes as studied slides, but the shapes were rearranged on the slide, as with the example event and incongruent slide depicted in Figure 3.

Procedure. Participants studied four of the

six events in their entirety, and none of the slides from two other events. At test, participants viewed the fourth slide from two studied events (old), two incongruent slides from studied events, and two slides from nonstudied events (new). Slide type was counterbalanced across participants as in Experiment 1. After viewing each test slide, participants

were asked if they had previously seen the slide during the study phase. Responses (either "yes" or "no") were recorded on a datasheet.

Results

The mean numbers of "yes" responses from children and adults (depicted in Figure 4) were submitted to a 2 x 3 ANOVA with age as a between-subjects variable and slide type as a within-subjects variable. As in Experiment 1, children were significantly more likely than adults to respond "yes," $F(1, 45) = 14.96$, $p < .001$, $\eta_p^2 = .25$. The effect of slide type was significant, $F(2, 90) = 38.70$, $p < .001$, $\eta_p^2 = .46$. Planned contrasts showed that the difference between old and incongruent slides was significant for both children and adults: $F(1, 90) = 16.86$, $p < .001$, $\eta_p^2 = .16$ for children, and $F(1, 90) = 215.20$, $p < .001$, $\eta_p^2 = .70$ for adults. Although the effect size was smaller for children than adults, children could distinguish between old and incongruent slides. Also, the difference between incongruent and new slides was significant for both children and adults: $F(1, 90) = 55.75$, $p < .001$, $\eta_p^2 = .38$ for children, and $F(1, 90) = 11.79$, $p < .001$, $\eta_p^2 = .11$ for adults. As in Experiment 1, the age x slide type interaction was significant, $F(2, 90) = 12.96$, $p < .001$, $\eta_p^2 = .22$, indicating that the difference between children and adults varied across slide type. We carried out simple effects analyses to further investigate this interaction. The differences between children and adults were not significant for either old or new slides, both $Fs < 1$, but children were significantly likelier to say "yes" to incongruent slides than adults, $F(1, 45) = 4.93$, $p = .029$, $\eta_p^2 = .087$.

Discussion

As in Experiment 1, the main effect of age was driven primarily by children to be likelier than adults to respond "yes" to just one slide type, but unlike Experiment 1, it was incongruent slides rather than new slides for which children were likelier than adults to respond "yes." Nevertheless, children were able to distinguish between old and incongruent slides as indicated by the significant contrast. The significant contrasts between old and incongruent slides for both children and adults from Experiment 2 supported our hypothesis that both children and adults would recognize old slides more than incongruent slides, which in turn supported the hypothesis from Experiment 1 that both children and adults recognized missing

FIGURE 3
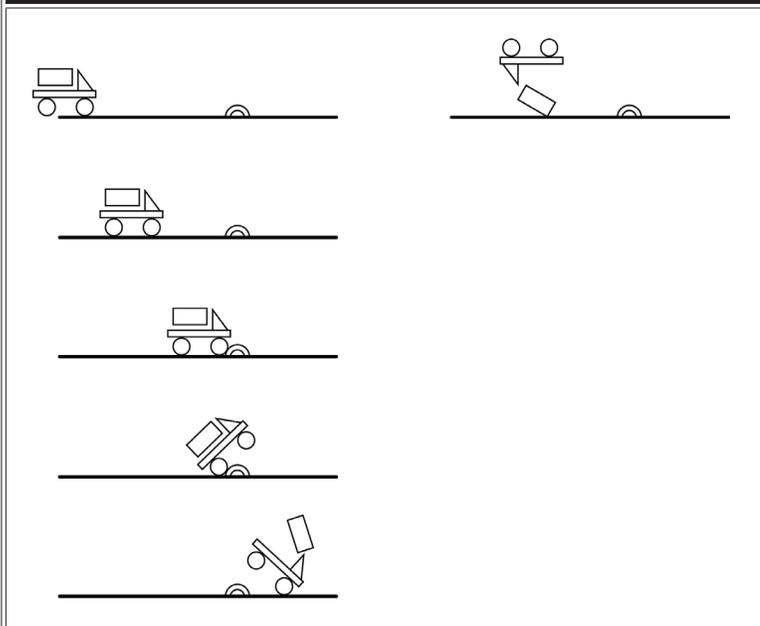
An event from Experiment 2 in which a truck drives across the computer screen, hits a bump, and loses its cargo. To the right is an incongruent slide. Two thirds of participants studied all five slides of this event and one third did not study this event. At test one third of participants viewed the fourth slide (old), one third viewed the incongruent slide, and one third viewed the fourth slide without having studied the event (new).

FIGURE 4
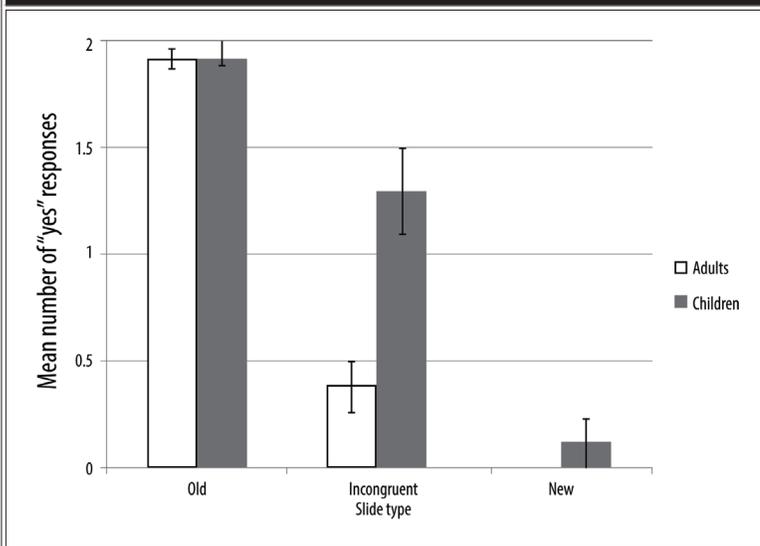
Mean number of "yes" responses from Experiment 2. Error bars represent standard error of the mean.

slides because they fit into the flow of studied events. However, the significant difference between incongruent and new slides suggests that both children and adults occasionally falsely recognized incongruent slides. Perhaps both the semantic and superficial similarity between studied slides and missing slides in Experiment 1 contributed to the recognition of missing slides.

General Discussion

Children are generally more likely than adults to create false memories (Otgaar et al., 2016), but one exception to this trend is the DRM (Deese, 1959; Roediger & McDermott, 1995) paradigm, in which participants who study several word lists often falsely remember a nonstudied associate (Otgaar & Smeets, 2010). Presumably, this results from children having underdeveloped semantic networks relative to adults (Fisher et al., 2015), but we thought children might have similar understanding of simple events as adults (Berry & Springer, 1993). Indeed, children can extract the global gist from their experiences (Odegard et al., 2009), so we hypothesized that, if pieces are missing from witnessed events, children would rely on the gist to fill in the missing pieces in their memories of the events.

In Experiment 1, children and adults recognized missing slides more often than new slides, supporting our hypothesis. The significant main effect of age was driven primarily by children being likelier to respond "yes" to new slides, which could either indicate children having more false memories than adults (Otgaar et al., 2016), or children trying to be agreeable to the experimenter (Brackmann et al., 2016). Unfortunately, it is difficult to distinguish between these possibilities, but the contrast between the two experiments' results might provide some insight, as described below. Another notable feature of the results from Experiment 1 was the similarity across both ages for the responses to old and missing slides. Strictly speaking, responding "yes" to a missing slide is a kind of false memory because the missing slides had not actually been studied, but it also represents the successful extraction of gist from witnessed events. Although both younger and older children can extract the gist from experienced events, older children recall more details than younger children (Odegard et al., 2009). The lack of significant differences in Experiment 1 between children and adults for old and missing slides could either show that, in contrast to Odegard et al. (2009), children

retain as many details as adults for our task and stimuli, or there was a ceiling effect. Replicating Experiment 1 with more study events and test slides would distinguish between these two possibilities as well as overcome other limitations described below, but our materials seemed to push children participants to the limit of their attention.

The results from Experiment 1 supported our hypothesis that children rely on global gist extracted from witnessed events to fill in missing pieces in their memories. However, children are likelier than adults to falsely recall nonstudied words that are superficially related to studied words (Brainerd et al., 2002), so an alternative explanation is that children recognized missing slides because they contained all the same items as studied slides. If this alternative hypothesis is true, children should recognize slides that contain all the same items as studied slides but the items are moved about so the slide does not fit into the flow of the event. In Experiment 2, children and adults could distinguish between old slides and incongruent slides, suggesting that this hypothesis cannot explain the lack of any difference between old and missing slides in Experiment 1. However, children and adults recognized incongruent slides more often than new slides, suggesting that superficial similarity may explain some of the recognition of missing slides in Experiment 1. Also, children recognized incongruent slides more than adults, which confirms the claim that children's recognition relies more on superficial similarity than for adults. Unlike Experiment 1, children were not likelier than adults to recognize new slides in Experiment 2. Because all child participants in Experiment 2 had previously participated in Experiment 1, apparently some children learned from their experience in that experiment that not all test slides had been shown during study. Children's rejection of new slides in Experiment 2 suggests that their willingness to recognize new slides in Experiment 1 is better explained by their desire to be agreeable with the experimenter (Brackmann et al., 2016) than a false memory (Otgaar et al., 2016).

Limitations

Researchers who study memory often transform raw response rates into a signal detection model that includes signal and noise distributions and a decision criterion (Otgaar et al., 2016). The dependent variable is called d' (d prime), which represents the distance between the two distribution means. Because d' is independent of the

decision criterion, the signal detection model controls for biased decision-making strategies such as guessing (Swets, 1996). This is particularly relevant to our method because forcing participants to select either "yes" or "no" without an option to answer "I don't know" could be expected to encourage guessing. One limitation of our study was that, for all conditions, each response (either yes or no) could be offered between zero and two times, a response range that is too narrow to create a meaningful signal detection model. Although an improved study would include more events per condition that could support a signal detection model, another limitation of our study was the short attention spans of the child participants. After viewing four events and six test slides, most children participants had reached their limit. One way to remedy both of these limitations might be to include participants who are a little older than the 4- and 5-year-old participants in our study. After all, Odegard et al. (2009) found that children between the ages of 5 and 6 can extract the gist from their prior experiences. Children who are a bit older may be able to focus their attention for long enough to view several more study events and test slides than in our experiments.

A second set of limitations concerns our sample. First, the reader should be cautious when interpreting our results given the limited sample size. Second, although we gathered each participant's age and sex, we neglected to record other demographic information such as race and ethnicity, so we are unable to determine how these variables might have influenced our results. Third, the relative proportion of female to male participants was about even for the children, but for the undergraduate students, the proportion was about 10 to 1. Further, the representation of female undergraduate students in our study was disproportionate to the overall student population at UCA, which is about 60% female. This seems likely to be a symptom of the larger pattern that women are better educated than men (Darroch, 2014). Apparently, the female undergraduate students at UCA were more conscientious in meeting their course requirements than male undergraduate students (participation in experiments is a requirement for the General Psychology course, but alternative activities are available for anyone who prefers not to participate). This means that, although we had only intended to manipulate age, there was a confounding manipulation of conscientiousness between the children and adults. The solution to this problem is not readily apparent because female undergraduate students are disproportionately likelier than male undergraduates to participate in experiments for course credit.

Future Directions

Our study raises some questions that remain unanswered, and that we would like to try to answer in future experiments. First, why were both children and adults significantly likelier to respond "yes" to incongruent slides than new slides? Perhaps participants misinterpreted our question "Did you see this slide?" as "Did you see the items in this slide?" If so, they may have answered "yes" only when the items on the test slide were arranged in roughly similar configurations as in the study slides, which suggests that the likelihood of participants answering "yes" may vary with the degree of incongruence between the study and test slides. To test this, we could present events with a missing fourth slide, then at test, manipulate the incongruence between the study and test slide across participants. Second, do participants fill in only the pieces of events that occur within the context of the witnessed slides, or do they fill in beyond the witnessed slides? To test this, we could present events consisting of five slides, then at test show participants a "missing" sixth slide that had not been studied but could plausibly have occurred as a result of a witnessed event. One of the main contributions of our study to the field is the introduction of a stimulus that can be altered in countless ways, limited only by the researcher's imagination. We would like to create new slideshows to test these and other questions, and hope that other researchers do so as well.

In summary, we found that children were as likely as adults to fill in missing details from the global gist extracted from witnessed events. Children are likelier than adults to falsely recognize test slides due to superficial similarity with studied slides, which can explain some but not all of children's recognition of missing slides. Because participants did falsely recognize a missing slide, this suggests children and adults are indeed susceptible to false memories. Our research also suggests that children can adapt their memories to remember parts of an event that were hidden from perception. The entire event may be accessible for later recall. Using pictures when interviewing child witnesses may enable the interviewer to extract more detail than could be available through traditional verbal techniques.

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