The Development of Automatic and Controlled Inhibitory Retrieval Processes in True and False Recall

Lauren M. Knott, Mark L. Howe, Marina C. Wimmer, Lancaster University

Stephen A. Dewhurst, University of Hull

Address correspondence to: Prof. Mark L. Howe

Department of Psychology

Lancaster University

Lancaster UK LA1 4YF

e-mail: mark.howe@lancaster.ac.uk

Authors' Note

This research was supported by a grant to MLH from the Economic and Social Research Council of Great Britain (RES-062-23-0452). Correspondence concerning this research should be addressed to Prof. Mark L. Howe, Department of Psychology, Lancaster University, Lancaster, UK LA1 4YF.

IN PRESS: *Journal of Experimental Child Psychology*

Abstract

In three experiments we investigated the role of automatic and controlled inhibitory retrieval processes in true and false memory development in children and adults. Experiment 1 incorporated a directed forgetting task to examine controlled retrieval inhibition. Experiments 2 and 3 utilized a part-set cue and retrieval practice task to examine automatic retrieval inhibition. In the first experiment, the forget cue had no effect on false recall for adults but reduced false recall for children. In Experiments 2 and 3, both tasks caused retrieval impairments for true and false recall, and this occurred for all age groups. Implicit inhibition, which occurs outside of our conscious control, appears early in childhood. However, because young children do not process false memories as automatically as adults, explicit inhibition can reduce false memory output.

Keywords: Retrieval inhibition, False memory development, DRM paradigm, Directed forgetting, Automaticity, Associative-Activation Theory.

The Development of Automatic and Controlled Inhibitory Retrieval Processes in True and False Recall

Previous research shows that children, in comparison to adults, are less susceptible to the spontaneous production of false memories in the Deese/Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995). In the paradigm, participants study lists of words that are semantic associates of a nonpresented ‘critical lure’. For example, words such as *hot, snow, warm, winter, ice, chilly,* and *freeze,* are all associates of the critical lure *cold.* This effect is robust at all ages and false recall of critical lures (CLs) typically increases with age throughout the primary school period (e.g., Brainerd, Reyna, & Ceci, 2008), although recently, a number of important exceptions to these age trends have been reported in the literature (see Bouwmeester & Verkoeijen, 2010; Wimmer & Howe, 2010).

Two theories have emerged to account for the developmental increase in the spontaneous generation of false memories in the DRM paradigm. Fuzzy-trace theory (FTT; Brainerd & Reyna, 2005) suggests that presented information is encoded by two different memory traces: verbatim and gist. Briefly, verbatim traces are concerned with item-specific information (e.g., phonological information) and gist traces are concerned with meaning-based information (i.e., the overall theme). It is these gist traces that are primarily responsible for false recall in the DRM paradigm. Because the ability to extract gist increases with age, the likelihood of false memory production also increases with age.

Alternatively, associative-activation theory (AAT; Howe, Wimmer, Gagnon, & Plumpton, 2009), based in part on the activation-monitoring theory (AMT; Roediger & McDermott, 1995), suggests that increases in true and false memories are the result of automatic spreading activation processes. As children’s knowledge base develops, so too does their experience and practice at utilizing and activating concepts within that knowledge base (Bjorklund, 1987, 2005; Howe 2005, 2006; Howe et al., 2009). False memories occur because the critical lure is repeatedly activated due to its association with presented list items from the same associative network. With age, children's ability to activate associative networks becomes more automatic and they are thus better able to use associative relations much in the same manner as adults.

Thus, FTT explains developmental changes in terms of the ability to better extract and retain the gist of semantically related words, whereas AAT explains these same developmental changes in terms of increases in knowledge base (both nodes and their interconnections) and improvements in direct access of activation processes in semantic networks. Both AAT and FTT agree that false memories can only occur if there is a pre-existing lexicon of associations that can be mentally activated (Howe et al., 2009). We can see that both theories provide an explanation for the quantitative increase in false memories when they are observed. Research, however, has only recently considered differences in the quality of children's and adults' false memories. That is, regardless of how many are produced, are there qualitative differences in how false memories arise across development? When children's false memories occur, are they qualitatively similar (i.e., are they similar in strength, are they activated, stored and retrieved in the same manner) to adults?

For adults, it appears that false memories occur relatively automatically, both at the encoding stage and at the retrieval stage, outside of conscious awareness. For example, at encoding, false memories can still occur when information is encoded incidentally (e.g., Dodd & MacLeod, 2004). Adults are still able to falsely recognize critical lures following rapid list exposures (e.g., Seamon, Luo, & Gallo, 1998) or even after they have been forewarned of the false memory effect (e.g., Gallo, Roberts, & Seamon, 1997). Studies have also shown that false memories occur automatically at retrieval. For example, the typical list-based directed forgetting task has been used with the DRM paradigm. After studying a

DRM list, some participants are instructed to “forget” that list, while others are instructed to “remember” the list. Directed forgetting instructions are shown to inhibit true recall for studied words, but not false recall of critical lures (Kimball & Bjork, 2002; Seamon, Luo, Shulman, Toner, & Caglar, 2002, although see Lee, 2008; Marche, Brainerd, Lane & Loehr, 2005, for reduced false recall with an item-based directed forgetting task).

So far, we know of only three studies that have investigated the automaticity of children’s false memories. Wimmer and Howe (2009) measured the speed of processing of associative responses in the DRM paradigm. Speed was used as an index of automaticity. That is, if memory networks for associations are strong, then associative activation should be less effortful and hence faster. Results showed that children’s ability to generate word associates, and the speed at which they were generated, increased with age. Interestingly, however, when associations mapped specifically onto their knowledge base, children as young as five years were able to generate fairly automatic associates.

Wimmer and Howe (2010) further assessed the robustness of children’s and adults’ false memories at the encoding stage. Manipulating levels-of-processing and divided attention at study reduced both adults’ and children’s true memories. In contrast to adults, children’s false recognition was less robust under divided attention and shallow processing. Wimmer and Howe (2010) argued that there are some qualitative differences in children’s and adults’ false memories at the encoding stage. Results from both studies suggest that, consistent with predictions from the associative-activation theory, during the encoding phase, automaticity of associative activation increases with age and the false memories produced by children differ not only quantitatively but also qualitatively depending on corresponding age differences in the knowledge base.

At retrieval, the story may be similar. Howe (2005) investigated the automaticity of children’s false memories using the directed forgetting task. When instructed to forget, children, unlike adults (Kimball & Bjork, 2002), showed a reduction in both true and false memories at output. Howe argued that children were able to consciously and intentionally inhibit false memories at output, but no effect on false memories for adults meant that false memories were retrieved more automatically, outside of conscious awareness. It seems that qualitative differences in children's and adults' false memories may also be apparent at the retrieval stage.

The directed forgetting task used by Howe (2005) examines the intentional inhibition of recall using consciously controlled processes (i.e., participants are explicitly instructed to "forget" information). The part-list cuing and retrieval practice paradigms have also been used with DRM lists to investigate the effects of retrieval inhibition that is more implicit and automatic (i.e., there are no explicit instructions to "forget" information) on false memory. For part-list cuing (which we will now refer to as *whole-word cuing*), participants study DRM lists and at test are provided with exemplars from each list as whole word cues for recalling the remaining cue absent items. For the retrieval practice paradigm, participants are presented with partial word stems to complete at test from each list (e.g., sn_ _ _ _ for *snooze*) before been asked to recall the remaining cue absent items (which we will now refer to as *partial-word cuing*). A control condition allows participants to freely recall the list items with neither whole-word nor partial-word cuing. In previous research, partial-word (Bauml & Kubander, 2003) and whole-word cuing (Bauml & Kubander, 2003; Kimball & Bjork, 2002) have been shown to reduce not only true recall for list items, but also false recall of the critical lures.

Kimball and Bjork (2002) argued that the hyperaccessible cues not only impair episodic access to list items but also to the critical lures. At study, the critical lures are highly likely to become activated and associated with list items. At test, the cues will similarly affect the critical lures that are associated with the list items rendering them less accessible and thus causing a decline in their output rates.

These paradigms have been used in studies to examine retrieval inhibition in children's true recall. For example, Zellner and Bauml (2005) used variants of the partial-word and whole-word cuing methods. In both cases, the inhibitory effects were compared across three age groups; first or second graders (6-7 year-olds), fourth graders (9-10 year-olds), and young adults. Children in both age groups showed the same amounts of forgetting due to partial-word and whole-word cuing as the adult group. As Zellner and Bauml argued, these results indicate that children as young as 7 years old already demonstrate the underlying processes involved in automatic retrieval-inhibition.

Although studies have investigated retrieval-inhibition in children, as far as we know, Howe (2005) presents the only study that investigates the effects of retrieval inhibition on false memories in children and is limited inasmuch as it investigated only explicit or controlled retrieval inhibition processes. The purpose of this study is to further investigate the age related, qualitative differences in false memory production by examining the influences of intentional and unintentional retrieval inhibition tasks on true and false recall using the DRM paradigm.

We would predict that with the intentional directed forgetting task, both children and adults will be able to inhibit true memories when instructed to forget but only children will be able to inhibit false memories to the same degree. We make these assumptions based on the conclusions reported by Howe (2005) and Kimball and Bjork (2002). Directed forgetting affects episodic access but not semantic activation. Therefore, the forget instruction should lower the amount of true recall that relies on episodic access but have no affect on false recall that relies on semantic activation. This holds true for adults, given that semantic activation of associated critical lures occurs automatically. For children, however, where

DRM associates are not as automatically activated, critical lures, when generated, enter conscious awareness and are treated as list members (see Underwood's, 1965, implicit-associative response theory). As children are able to inhibit episodic list output given a forget instruction, children should be able to inhibit false memories to the same degree as true memories.

In comparison, the inhibitory effects caused by partial-word and whole-word cuing are strictly unintentional. We know that for adults, this form of retrieval inhibition reduces recall for both list items and critical lures (Kimball & Bjork, 2002). As mentioned earlier, retrieval impairment occurs because list-cues and word stems for studied items enhance access for those particular items, at the expense of access for cue absent items. When activated, critical items will also be suppressed at retrieval due to the hyperaccessible cue present items rendering them less accessible. Inhibition here does not reflect access to an entire episodic list, but rather, elements of that episode list (the cue absent items). We have not yet seen the effects of automatic retrieval inhibition on children's false recall, however, we would predict that when produced, children's DRM illusions, like adults', would be suppressed at retrieval.

In the present investigation we report three experiments, one that examines intentional or controlled retrieval inhibition processes (Experiment 1) and two of which examine unintentional or automatic retrieval inhibition processes (Experiments 2 and 3). Experiment 1 attempts to replicate Howe's findings with the added inclusion of an adult population. Experiments 2 and 3 add a whole-word cue and partial-word cue manipulation to the standard DRM task.

Experiment 1

Experiment 1 was essentially a replication of Howe's (2005) directed-forgetting study with the following modifications. Howe used this procedure with children (5-, 7-, and

11-year-olds), with Kimball and Bjork (2002) providing data from an adult population. However, the following replication uses just two age groups: children (aged 7 years) and adults to allow for a more direct comparison of the differences, if any, in the directed forgetting instruction on children and adult's false memory production. In addition, in an attempt to enhance awareness of the relationship between list members, we provided thematic cues for each of the lists.

The key difference between the retrieval inhibition examined in this experiment and those that will be studied in Experiments 2 and 3 is that here inhibition is driven by effortful, conscious processes. That is, the procedures that will be used in Experiments 2 and 3 are designed to elicit automatic retrieval inhibition that is expected to occur outside of conscious awareness. In Experiment 1, we will first investigate conscious inhibition using the directed forgetting task and ask participants to consciously suppress the output of specifically studied episodic lists. Based on Howe's (2005) findings and conclusions, we would predict that with recall for presented items that children, like adults, will be able to inhibit recall when instructed to do so. For false recall, however, children should inhibit production when instructed to forget, just as they do for true memories. In contrast, for adults whose false memory production increases because of continued automatic semantic processing of the list, there should be no suppression of false recall.

Method

Participants

A total of 105 children (51 males/54 females; M_{age} = 7.7 years, SD = 6 months) were recruited. The children, predominantly White and from middle-class backgrounds, were tested following parental consent and their own assent on the testing day. A sample of 114 adults (39 males/75 females; M_{age} = 20.5 years, SD = 3 years) were also recruited and tested following informed consent. The adults were undergraduate students receiving either course credit or financial reimbursement for their participation.

Design

A 3(Instruction: Control vs. Directed Remembering vs. Directed Forgetting) x 2(Age group: children vs. adults) x 2(List Position: List 1 vs. List 2) design was used where the first two factors were manipulated between-participants and the last was manipulated within-participants for the directed forgetting and remembering conditions, but between-participants for the control condition, where participants only studied one list. There were 36 children in the directed remembering condition, 35 in the directed forgetting condition, and 34 controls. For adults, there were 40 participants in the directed remembering condition, 40 in the directed forgetting condition, and 34 in the control group.

Materials and Procedure

Participants were presented with 2, 10-item lists, one list at a time. List 1 was the list subject to different experimental manipulations (directed remembering/forgetting). Because participants only contributed one observation (only one critical lure) for the false recall analysis for each of List 1 and List 2, we included list theme cues (e.g., “words to do with temperature”) to increase the likelihood that children would falsely recall the critical lure (also see Holliday, Reyna, & Brainerd, 2008). Six DRM lists were used and were paired into three sets (*cold-sleep, doctor-foot,* and *king-sweet*). The pairings were made so as to reduce any semantic overlap and thus semantic associations between words from either list. The study order of the lists for each of the three list pairs was counterbalanced across participants, resulting in eight different combinations of list study order (with one list omitted in each combination for the control conditions). An equal number of participants were assigned to each list-study-order combinations. All lists were presented orally at a 2.5 second rate on a tape recorder.

At the start of the experiment, participants were given general memory instructions where they were asked to try and remember the concepts presented on the list. After presentation of the last item on the first list, participants in the remember condition were told to continue remembering the items they just heard and to try to remember the items on the next (second) list. Participants in the forget condition were told that the first list was just a practice so they should forget it and that they should only try to remember items on the next (second) list as this would be the one they will be tested on later. Following presentation of the second list, participants were instructed to recall items from a specified list, either List 1 or List 2. After recall of that list, they were asked to recall items from the other list. Participants in the control condition received only one list, either in the List 1 or List 2 study position. In lieu of seeing the other list, they circled pairs of letters and in lieu of the interlist cue they received instructions regarding the second task.

Results and Discussion

Because list-pair topics, within-list-pair presentation order, and recall order were counterbalanced in this experiment, we analyzed the data to see if there were any effects due to these methodological necessities. The results showed no effects due to these counterbalancing variables and they were therefore eliminated from subsequent analyses. As well, like in the previous experiments, analyses indicated that there were no main effects or interactions involving gender so this variable was also eliminated from subsequent analyses.

Correct Recall of list items

Overall, the proportions of studied items recalled for List 1 (M = .46, SD = .21) and List 2 (M = .47, SD = .20) did not differ reliably, $t(219) = 1.14$. The correct recall data were analyzed using a 2(Age group: children vs. adults) x 3(Instruction: Control vs. Directed Remembering vs. Directed Forgetting) between-subjects analysis of variance (ANOVA) for

List 1 and List 2 separately. For List 1, there was a reliable main effect of Age, $F(1, 213) = 210.40$, $p < .001$, $\eta_p^2 = .50$. As would be expected, adults recalled more items than children ($M = .60$, $SD = .15$, and $M = .31$, $SD = .15$, respectively). Of more interest for our purposes, was a reliable main effect of Instruction, $F(2, 213) = 3.39$, $p < .05$, $\eta_p^2 = .03$. This effect reflects typical directed forgetting. As can be seen from Figure 1, and was confirmed using post hoc tests, recall was lower for both children and adults in the forget condition (overall, $M = .42$, $SD = .22$) compared to the remember condition ($M = .48$, $SD = .20$, $p = .06$). There were no other reliable differences for Instruction and no Age x Instruction interaction, $F < 1$.

For the analysis of correct recall from List 2, as expected, there was a reliable main effect of Age, $F(1, 213) = 114.22$, $p < .001$, $\eta_p^2 = .35$, with adults recalling more studied items than children ($M = .59$, $SD = .18$, and $M = .35$, $SD = .14$, respectively). There was no significant main effect of Instruction or reliable interaction, both, $Fs \leq 1.81$.

False recall of critical lures

Due to participants only providing one observation for Lists 1 and 2, false recall data were initially analyzed using chi-square analyses and the related weighted-least-squares method. However, similar to the studies by Howe (2005) and Kimball and Bjork (2002), these analyses yielded results similar to separate between-subjects ANOVA. As this ANOVA revealed the same pattern of findings as the nonparametric analyses, for purposes of comparison with the correct recall analysis and previous studies, only the results from the ANOVA are presented here.

Overall, the proportions of items falsely recalled for List 1 ($M = .34$, $SD = .47$) and List 2 ($M = .30$, $SD = .46$) did not differ reliably, $t(219) = 1.02$. Similar to correct recall, the false recall data were analyzed using a 2(Age group: children vs. adults) x 3(Instruction: Control vs. Directed Remembering vs. Directed Forgetting) between-subjects ANOVA for List 1 and List 2 separately.

For List 1, there were no reliable effects of Age or Instruction, *Fs* < 1. There was, however, a reliable Age x Instruction interaction, $F(2, 213) = 7.35$, $p < .001$, $\eta_p^2 = .07$. Analysis of the simple main effects for each Age group revealed a significant effect of Instruction for children, $F(2, 102) = 4.30$, $p < .05$, $\eta_p^2 = .08$. Further post-hoc tests indicated that recall of the critical lures was lower in the forget ($M = .14$, $SD = .35$) compared to remember ($M = .44$, $SD = .50$ $p < .05$) instruction. This can be seen in Figure 1 for falsely recalled items in children and demonstrates typical directed forgetting. For adults, there was also a reliable effect of Instruction, $F(1, 111) = 3.72$, $p < .05$, $\eta_p^2 = .06$. Post hoc tests indicated reliably higher recall for critical lures in the forget ($M = .50$, $SD = .51$) compared to control ($M = .21$, $SD = .41$ $p < .05$) condition. There were no other differences. Although we would expect false recall rates to be as high as those for remember and forget conditions, this finding is not too surprising given that adults were presented with only one 10-item list that was accompanied by a theme cue. It is likely that these factors will have aided accuracy and contributed to the low false recall rates in the control condition.

For List 2, there were no significant main effects for Age or Instruction (both *Fs* < 1). The interaction was approaching significance, $F(2, 213) = 2.50$, $p = .09$, but the simple main effects tests revealed no significant differences.

Consistent with recent studies (Howe, 2005; Howe, Toth, & Cicchetti, in press; Kimball & Bjork, 2002; but see Harnishfeger & Pope, 1996 for different results) children and adult participants showed typical directed-forgetting effects for studied items whereby significantly fewer items were recalled from List 1 after the forget instruction. Furthermore, as we predicted, the forget instruction had no effect on false recall for adults but did reduce false recall for children. It bears mentioning that Kimball and Bjork (2002) found an increase in false recall after the forget instruction in adults. Although the reported results here showed no reliable effect of the forget instruction in adult false recall, a similar trend can be seen (see Figure 1). Taking into account previous findings and the present results, it would seem that when retrieval inhibition occurs due to explicit instructions there exist developmental differences in false recall.

Experiment 2

In Experiment 2 we studied the automatic inhibitory retrieval effects of whole-word cuing. As Experiment 2 is not a replication and extension of previously published research, and because we were interested in these effects across a broad age range, we incorporated three developmental age groups: 5-, 7-, and 11-year-olds. All four age groups (including adults) were presented with DRM and category lists and recalled the lists in either a free recall control condition or a whole-word cue condition in which half of the studied items for each list were provided as retrieval cues at test to recall the remaining items.

The detrimental effects of whole-word cuing occur not only for adults but also for children (e.g., Zellner & Bauml, 2005). However, so far, this has only been shown for true (or correct) recall but not for false recall. Recently, the role of retrieval inhibition on false memories has been investigated with adults where studies have shown that whole-word cuing can reduce both true recall of list items and false recall of DRM critical lures, in the same manner, both in pattern and in size (e.g., Bauml & Kuhbander, 2003; Kimball & Bjork, 2002). In Experiment 2 we investigate whether the same could be true for children.

In addition, previous research has shown that false memories can occur not only for DRM lists, but also for categorical (or thematic) material. The difference between the two list types are that association norms for DRM lists consist of a multiplicity of relations between concepts (synonyms, antonyms, property relations, and functional relations), whereas category lists are restricted to categorical relations (categorical membership, superordinate relations, and subordinate relations). For example, *dog* and *bark* share an associative relation whereas *dog* and *cat* share a semantic categorical relation.

False memory research has previously used such lists to demonstrate the role of semantic relations versus associative relations in false memory production. The consensus so far is that associative strength is primarily responsible for false memory production and values of backward associative strength (BAS) have been found to be the strongest predictor of false memories (Roediger, Watson, McDermott, & Gallo, 2001). Although research has shown no differences in children's or adults' false memories for category lists compared to DRM lists (e.g., Howe, 2006; Hutchison & Balota, 2005), category lists do produce better true recall than DRM lists (Howe, 2006; Howe et al., 2009). As children as young as five-years were tested in this experiment, category lists were also used to increase chances of accurate episodic recall.

Method

Participants

A total of 97 participants took part in the second experiment, 25 5-year-olds (14 males/11females; M_{age} = 5.10 years, SD = 3 months), 25 7-year-olds (10 males/15 females; M_{age} = 7.11 years, SD = 4 months), 25 11-year-olds (9 males/16 females; M_{age} = 11.3 years, SD = 4 months), and 22 adults (7 males/15 females; M_{age} = 20 years, SD = 4 years). All children, predominantly White and from middle-class backgrounds, were tested following parental consent and their own assent on the day of testing. Adult participants were undergraduate students who were tested following informed consent and were paid for their participation.

Design, materials, and procedure

A 2(Cue Condition: cue absent vs. cue present) x 2(List: DRM vs. category) x 4(Age: 5- vs. 7- vs. 11- year-olds vs. adults) design was used where cue condition and list type were within-participant factors and age was a between-participants factor. The dependent variables were the number of falsely recalled critical lures and correctly recalled target items.

Participants were presented with 8, 10-item lists, one list at a time. The lists were blocked in groups of 4 dependent on list type (4 DRM and 4 category). The DRM lists were chosen based on their single themed content from norms produced by Stadler, Roediger, and McDermott (1999; see Appendix for lists and BAS values). Category lists were taken from Van Overschelde, Rawson, and Dunlosky (2004; see Appendix). The highest frequency exemplar was used as the critical lure for each category list, with list items presented in frequency order. Although all lists have been successfully used to produce false memory effects with children in these age ranges (e.g., Howe 2005, 2006; Howe et al., 2009) we are aware that in some instances certain items in DRM lists may be more difficult for younger children to comprehend. In light of this, we have taken steps to ensure that age related frequency values (see below) matched across all lists. Mean familiarity (taken from the MRC psycholinguistics database [Coltheart, 1981]) ratings and frequency values (taken from primary school aged children's vocabulary [Stuart, Masterson, Dixon, & Quinlan, 1993-1996]) did not differ between lists types, $t(14) = 1.44$, $p = .17$ and $t(14) = .78$, $p = .45$, respectively. Eight of each list type were chosen and divided randomly to make two sets of 4 to allow for counterbalancing.

Items from each list were presented on audiotape at a 3 second rate. Following a procedure similar to Dewhurst, Bould, Knott, and Thorley (2009), participants carried out a brief distractor task to reduce recency effects before the immediate recall task (counting backward from a given number for children and counting backwards in three's for adults) for 15 seconds prior to being asked to recall the items from the list. At test, participants completed either the control recall task or the cued recall task. In the cued recall condition participants were told that they would first hear some of the items that they heard from the study list to help them recall the remaining items. Due to age constraints, whole-word cues were presented orally to the participants before test using a similar method to Zellner and Bauml (2005). If participants repeated a cue, they were reminded that this was an item previously presented as a whole-word cue, and that item was not included in further analysis. Items for the whole-word cue were taken from positions 1, 3, 5, 7, and 9 of each study list and were presented in a random order at a rate of one item every 2 sec. Participants were asked to recall the remaining items (target items) after the auditory presentation of the whole-word cues. For each list type (four lists in each), items were recalled with the cue absent condition twice and the cue present condition twice. Across the course of the experiment, each participant received 4 cue absent recall tests and 4 cue present recall tasks. All presentation and recall was oral. The assignment of each list to the two cue conditions and subsequent order presentation of cue type was counterbalanced, so that all lists appeared equally often in each test condition and test phase. The order of presentation for each list type was counterbalanced.

Results and Discussion

Results from three participants were removed prior to analysis due the over production of already presented cues during recall and thus the failure to follow instructions. Preliminary analyses indicated that there were no main effects or interactions involving gender so this variable was eliminated from subsequent analyses. Proportions of correct and false recall (see Figure 2) were analyzed separately in 2(Cue Condition: cue absent vs. cue present) x 2(List: DRM vs. category) x 4(Age: 5- vs. 7- vs. 11-year-olds vs. adults) mixed factor ANOVAs.

Correct recall of presented items

Consistent with previous research, there was a significant main effect of List, $F(1, 90) = 5.50$, $p < .05$, $\eta^2 = .06$, with greater rates of correct recall for category lists ($M = .50$, *SD* = .18) compared to DRM lists (*M* = .47, *SD* = .19). There were also significant main effects of age, $F(3, 90) = 67.28$, $p < .001$, $\eta_p^2 = .69$, and cue condition, $F(1, 90) = 93.45$, $p < .001$, $\eta_p^2 = .51$. These main effects were qualified by a significant Age x Cue condition interaction, $F(3, 90) = 3.01$, $p < .05$, $\eta_p^2 = .09$. Bonferroni post-hoc tests indicated a significant increase in correct recall across all age groups for the no cue condition (age 5, *M* = .39, *SD* = .12; age 7, *M* = .50, *SD* = .11; age 11, *M* = .60, *SD* = .12; adults, *M* = .70, *SD* = .13, all *p*s < .05). For the cue condition, there was no developmental increase in correct recall between 5- and 7-year olds (*M* = .26, *SD* = .16 vs. *M* = .33, *SD* = .14), but significant increases in all other age groups (age 11, *M* = .45, *SD* = .16; adults, *M* = .70, *SD* = .16, all *p*s < .05). Importantly, at all age groups, correct recall was greater in the cue absent compared to cue present condition. There were no other significant interactions.

False recall of critical lures

Analysis showed a main effect of list, $F(1, 90) = 4.00$, $p < .05$, $\eta_p^2 = .04$, and age, $F(3, 90) = 3.06$, $p < .05$, $\eta_p^2 = .09$. Although post-hoc tests did not reveal typical developmental differences in false recall, an Age x List interaction, that was approaching significance, $F(3, 90) = 2.24$, $p = .09$ $\eta_p^2 = .07$, demonstrated developmental increases in false recall for DRM lists where adults (*M* = .33 *SD* = .34) recalled more critical lures than both 5- (*M* =.13, *SD* = .21) and 7-year olds (*M* = .14 *SD* =.24, *p* < .05), with 11-year-olds (*M* = .29 *SD* = .32) also falsely recalling more (although not significantly so) than the younger age groups (*p* < .09 and *p* < .15 respectively). No effects were observed for the category lists. Finally, there was a significant main effect of cue condition, $F(1, 90) = 16.91$, $p < .001$, $\eta_p^2 = .16$, where false recall was greater in the cue absent (*M* = .24, *SD* =.25) compared to cue present (*M* = .15, *SD* =.25) condition. There were no other significant effects.

Previous studies have shown that whole-word cuing can impair both retrieval of studied items and the retrieval of nonstudied critical lures (Bauml & Kuhbander, 2003; Kimball & Bjork, 2002). Our results extend these findings by demonstrating that children as young as five years also show implicit forgetting for both true and false memories and that this type of forgetting is largely the same across all age groups (i.e., there was no Age x Cue condition interaction, $F(3, 90) = .31$, $p = .82$). As we are basing our conclusions on a nonsignificant interaction we conducted a post-hoc power analysis to demonstrate that our sample size was sufficient to detect a reliable effect. Using G* Power (Faul, Erdfelder, Lang, & Buchner, 2007), with $N = 94$ (given .05 alpha and a calculated effect size of .17) the study had a power of .80 (any power value above .80 is consider to be sufficiently high).

Our findings support conclusions by Kimball and Bjork (2002) that the presence of whole-word cues impairs episodic access to remaining list items (targets). The hyperaccessible whole-word cues appear to render remaining study items less accessible. As we know, DRM and category critical lures are prone to false recall because they are highly likely to become activated and associated with list items at study. If whole-word cues affect the critical lures associations to the retrieval cues in a similar manner to the studied items' associations, then critical lures will also be less accessible and thus decline after cuing. Although children are typically less likely to produce DRM illusions compared to adults, what the current experiment shows is that if the critical lure is activated at study, the automatic inhibitory effects caused by whole-word cuing not only impairs veridical recall but also recall for critical lures in a similar manner to that found with adults.

Experiment 3

In accordance with the inhibitory account of whole-word cuing, Experiment 2 provides the first demonstration of retrieval inhibition in children's true and false recall. Similar to Zellner and Bauml (2005), our goal for Experiment 3 was to replicate this finding with a second retrieval-induced forgetting paradigm. Previous studies have shown that the retrieval of a subset of learned items, by providing word stems, inhibits recall for the remaining items. This form of retrieval-induced forgetting has been used with both adults (Anderson, Bjork, & Bjork, 1994) and children (Zellner & Bauml, 2005). Although whole-word and partial-word cuing are considered to be mediated by similar inhibitory mechanisms, partial-word cuing causes forgetting of related material through overt retrieval of the to-be-completed stem whereas whole-word cuing causes forgetting through covert retrieval of the cue material (see Anderson et al., 1994). Having said that, on the basis of the findings in Experiment 2 and the adult findings from Bauml and Kuhbander (2003), we expect to find the same results for partial-word cuing as we do for whole-word cuing.

Following Zellner and Bauml's (2005) Experiment 2, we used three testing conditions; a free recall control condition, a whole-word cue condition, and a partial-word cue condition that has been modified to allow for a direct comparison to the whole-word cue condition. Although this is a variant to the standard retrieval practice paradigm, the detrimental effect of retrieval inhibition has been shown to be similar (see Zellner & Bauml, 2005, for a discussion on this point). Although category lists produced greater correct recall rates, Experiment 2 showed that there were no interactions with list type for either true or false memories. Because false recall for DRM critical lures tends to be higher, we used only DRM lists in Experiment 3.

Method

Participants

A total of 91 participants took part in this experiment, 23 5-year-olds (10males/13females; M_{age} = 5.03 years, SD = 4 months), 23 7-year-olds (9males/14females; M_{age} = 7.05 years, SD = 5 months), 22 11-year-olds (11males/11females; M_{age} = 11.01 years, SD = 3 months), and 23 adults (3males/19females; M_{age} = 21 years, SD = 2 years). All children, who were predominantly White and from middle-class backgrounds, were tested following parental consent and their own assent on the day of testing. Adult participants were undergraduate students who were tested following informed consent and were paid for their participation.

Design, materials, and procedure

A 3(Retrieval condition: whole-word cue vs. partial-word cue vs. control) x 4(Age: 5- vs. 7- vs. 11-year-olds vs. adults) mixed factor design was used where the retrieval condition was a within-participant factor and age was a between-participants factor. The dependent variables were the number of falsely recalled critical lures and correctly recalled target items.

Six out of the eight DRM lists used in Experiment 2 were chosen randomly (see Appendix) and employed in Experiment 3. Items from each list were presented on audiotape at a three second rate. After the presentation of the last item on the list, participants were asked to carry out a 15 sec distractor task (counting backward from a given number for children and counting backwards in three's for adults) prior to the test. Similar to Zellner and Bauml (2005), the partial-word and whole-word cue were given at the test phase, therefore the three experimental conditions differed at the test phase only. Participants took part in all three conditions and the order of conditions was counterbalanced across participants. The procedure for the whole-word cue condition follows that from Experiment 2. The items (taken from positions 1, 3, 5, 7, and 9 of each study list and read in a random order) for the whole-word cues were presented aurally and intact to the participants at a rate of 1 item every 2 sec prior to recall. Participants were asked to recall the remaining items (target items), after the presentation of the whole-word cues.

There was a similar two-stage recall test for the partial-word cue condition. First, the participants were given a word stem completion task (partial-word cues) for half of the studied items. Words for the stem completion task were also taken from positions 1, 3, 5, 7, and 9 of each study list (nontarget items). Word stems consisted of the first two or three letters of each word, depending on word length. The cues were presented orally by the experimenter (the first two or three letters were pronounced phonetically) and participants were instructed to complete the stem with a word from the just heard list. If the participants did not retrieve the items then the experimenter informed the participant of the correct answer. After the stem completion task participants were asked to immediately recall the list's remaining items (target items). The control condition consisted of a simple free recall task where participants were asked to recall as many items as possible from the list.

There was 1 min for recall for each list. Lists were blocked by retrieval condition (two lists per condition) and at the end of each condition there was a 2 min break. All recall was oral. The assignment of each list to the three test conditions was counterbalanced, so that all lists appeared equally often in each test condition.

Results and Discussion

Results from six participants (three 5-year olds, two 11-year olds, and one adult) were removed prior to analysis due to a failure to follow instructions. Correct completion of word stems in the partial-word cue condition were 93% for 5-year-olds, 96% for 7-year-olds, 97% for 11-year olds, and 96% for adults. Although success rates increased slightly with age, this tendency was not reliable, $F(3, 81) = 2.14$, $p = .10$, $\eta^2 = .07$. Preliminary analyses indicated that there were no main effects or interactions involving gender so this variable was eliminated from subsequent analyses. Proportions of correct and false recall (see Figure 3) were analyzed separately in 3(Retrieval condition: whole-word cue vs. partial-word cue vs. control) x 4(Age: 5- vs. 7- vs. 11-year-olds vs. adults) mixed factor ANOVAs.

Correct recall for presented list items

Correct recall performance showed a similar pattern as that in Experiment 2. There was a significant main effect of age, $F(3, 81) = 69.05$, $p < .001$, $\eta_p^2 = .72$, with post hoc tests indicating better recall performance for adults (*M* = .63, *SD* =.18) compared to 11- (*M* = .39, *SD* =.12, $p < .05$), 7- (*M* = .30, *SD* =.09, $p < .05$), and 5-year-olds (*M* = .24, *SD* =.10, $p < .05$), with no difference between 5- and 7-year-olds ($p = .35$). The main effect of retrieval condition was also significant, $F(2, 162) = 69.12$, $p < .001$, $\eta_p^2 = .46$, with post hoc tests indicating that recall performance was higher for the control retrieval condition (*M* = .50, *SD* =.19), compared to both the whole-word cue (*M* = .35, *SD* =.21, $p < .05$) and partial-word cue (*M* = .32, *SD* =.20, $p < .05$) conditions and the latter two conditions did not differ ($p = .10$). The interaction was not significant.

False recall for critical lures

For false recall of critical lures, there was a significant main effect of age, $F(3, 81) = 3.12$, $p < .05$, $\eta_p^2 = .10$, with higher rates of false recall for adults (*M* = .28, *SD* =.30) compared to both 5- (*M* = .14, *SD* =.25) and 7-year-olds (*M* = .15, *SD* =.23), with pairwise comparisons approaching significance ($p = .06$, and $p = .07$, respectively). There was no difference between 11-year-olds (*M* = .21, *SD* = .26) and adults ($p = 1$). There was a significant effect of retrieval condition, $F(2, 162) = 7.89$, $p < .001$, $\eta_p^2 = .09$, where false recall was higher in the control condition (*M* = .29, *SD* =.29) compared to both the whole-word cue (*M* = .16, *SD* =.28, $p < .05$) and partial-word cue (*M* = .14, *SD* =.25, $p < .05$) conditions and the latter two conditions did not differ ($p = 1$). Again, the interaction was not significant. Similar to Experiment 2, a power analysis using G* Power was conducted to demonstrate that the sample size was sufficient to detect any interaction. With *N* = 85 (given .05 alpha and a calculated effect size of .17) the study had a power of .82.

Similar to retrieval inhibition caused by the directed forgetting task, the whole-word cue and partial-word cue procedures were successful at impairing the retrieval of studied items. In contrast, however, false memories for critical lures also declined. Furthermore, this effect was developmentally invariant. That is, children as young as five years of age exhibited the same inhibitory effect as that of older children and adults. As mentioned earlier, if the critical lure is activated at study, regardless of age, the automatic inhibitory effect caused by the hyperaccessible cues will impair output of both cue absent studied items and the associated critical lure. These findings present no problems for the current theories of false memory development. Whether critical lures are produced as a result of gist extraction or activation of associative relations at study, their retrieval will still be impaired due to the cued items competing at retrieval.

It is also important to note that age-related increases in false memories (e.g., Brainerd et al., 2008) were not quite as evident in Experiments 2 and 3, similar to other recent reports of developmentally invariant false memory effects (see Bouwmeester & Verkoeijen, 2010; Wimmer & Howe, 2010). We give two possible explanations for this. First, participants were only presented with 4-6 lists (of which over half were presented in the retrieval inhibition conditions). Although we felt younger age groups would struggle with the presentation of more lists, this may not have been sufficient to show the typical age-related increases. Second, individual differences within young age groups (5- and 7-year-olds) are likely to be more prominent than for older age groups (11-year-olds and adults; see also, Bouwmeester & Verkoeijen, 2010).

General Discussion

The current experiments were designed to provide a further assessment of the automaticity of children's false memory production and, in particular, examine the role that retrieval processes play in the automatic production of such memories. To do so we investigated the effects of impaired retrieval access in true and false recall in both children and adult populations. Whole-word and partial-word cuing reduced recall for both studied items and critical lures for children and adults. For directed forgetting, which is considered to be a more conscious, effortful, and explicit form of retrieval inhibition, the picture was somewhat different. Although findings showed a forgetting instruction effect for true recall regardless of age, there were differences in false recall. That is, directed forgetting instructions reduced false recall for children but had no effect on the production of false memories for adults. This has been interpreted in the past as indicating that false memories are automatically retrieved by adults (Kimball & Bjork, 2002) but become part of the episodically studied list for children (Howe, 2005). What this means is that for children, false memories can be consciously inhibited at retrieval because they are not processed as automatically as they are in adults. This in turn may be because adults' knowledge base is better articulated and organized than children's, leading to more automatic processing of semantic information, a phenomenon similar to that found at encoding (Wimmer & Howe, 2009, 2010).

The similarities and differences found in children's and adults' false recall performance across the three experiments may be due to differences in the inhibitory mechanisms involved and their subsequent effects on access to episodic and semantic recall. Unlike directed-forgetting, the inhibitory effects caused by the whole-word and partial-word cue are strictly unintentional in that it occurs despite participants' intention to maintain access. Kimball and Bjork (2002) argued that for whole-word and partial-word cuing, providing some list items as either cues or word-stems does not impede overall episodic access to that list. Retrieval impairment occurs in these instances because whole-word and partial-word cues of studied items enhance episodic access for those particular items, at the expense of the cue absent items. When produced, children's DRM illusions, just like adults, will be suppressed at retrieval due to the hyperaccessible whole-word and partial-word cues, rendering the activated critical lures less accessible.

Models of indirect suppression (e.g., Miller & Cohen, 2001) suggest that focusing attention on one response facilitates that response at the cost of suppressing other, related responses via automatic inhibition. Here, retrieval impairments caused by whole-word and partial-word cuing occurs because focusing attention on these items causes lateral inhibition of other interlinked exemplars in the same list. This model also extends to recall for critical lures because critical items, if activated at study, become part of these interlinked exemplars at test. The important point here is that this form of retrieval inhibition is automatic and unintentional, thus occurring outside of our conscious awareness. The findings from Experiments 2 and 3 demonstrate that this unintentional automatic inhibition appears early in childhood and remains intact for the greater part of the adult lifespan (e.g., Marsh, Dolan, Balota, & Roediger, 2004, for whole-word cuing effects in the elderly).

We have assumed that retrieval-induced forgetting is caused by inhibitory retrieval mechanisms. The present findings and those from previous studies (Bauml & Kuhbandner, 2003; Zellner & Bauml, 2005) support this assumption. However, we also acknowledge that there are other, noninhibitory accounts of retrieval-induced forgetting. For example, interference theories of forgetting (e.g., Tomlinson, Huber, Rieth, & Davelaar, 2009) argue that it is the learning of new information that causes forgetting. That is, the original memory is difficult to access and recall if there are other memories competing with it at retrieval. Although the current data do not distinguish between these accounts, the inhibitory account at present provides an explanation for the findings regarding the correlated declines in both true and false recall.

The dynamics of directed-forgetting appear to be quite different. Here the cue to forget intentionally impairs episodic access to the entire list, leaving semantic activation unimpaired (see results from indirect memory tasks; Basden Basden, & Gargano, 1993). With regard to the DRM task, if the forget cue affects episodic access but not semantic activation, then there should be a dissociation between studied items and critical lures during recall. That is, the directed-forgetting effect should lower true recall that relies on episodic access, but have no effect on false recall that relies on semantic activation (see Kimball & Bjork, 2002). For adults, previous findings (Kimball & Bjork, 2002; Seamon et al., 2002) along with the results from Experiment 1 support this assumption. True but not false memory rates are significantly reduced after the forget cue. Thus, adults are able to inhibit the output of studied information that is held in episodic memory. In contrast, critical lures are not impaired because they have been automatically activated in semantic memory and do not become part of the episodic list.

For children, previous findings (Howe, 2005; Howe et al., in press) and the results from Experiment 1 show that both true and false recall rates were reduced given the directed forgetting instruction. In comparison to adults, then, children, although automatically activating false memories at the generation stage, behave as if these unpresented items become part of their episodic experience. If false memories become part of the episodic list, then, like true list members, these unpresented items can be intentionally suppressed at output. Unlike partial-word and whole-word cuing, the inhibitory effect caused by the directed-forgetting instruction is intentional and thus designed to explicitly inhibit our episodic experience (something that we are consciously aware of). If, for children, false memories become part of their episodic experience, then these too will also be suppressed at output.

The current experiments add to the growing body of evidence that demonstrates the important role automaticity plays in the development of children's true and false memory production. There are, however, other processes that develop and contribute to age changes in false memory production. Recent research has demonstrated that certain metamemorial skills can affect false memory production. For example, children can correctly reject information that has been recognized as self-generated with a recollection-to-reject strategy (Brainerd, Reyna, Wright, & Mojardin, 2003). With age, children become more likely to use such strategies spontaneously (Carneiro & Fernandez, 2010; Carneiro, Fernandez, & Dias, 2009; Ghetti 2008). Thus, although processes develop over childhood that increase susceptibility to the DRM effect (organization and structure of knowledge base, automatic associative activation), there are opposing processes that can help reduce false memory (recollect-to-reject, memory editing, source-monitoring).

The present study did not directly involve or test metamemorial strategies. However, as Wimmer and Howe (2010) found, the memory advantage for self-generated (consciously recognized as internally generated) disappears if associative information is activated automatically outside of conscious control. As we used the standard DRM task with no metamemorial strategy, it is more likely that the reduction in false recall caused by the directed forgetting instruction (that occurred for children but not adults) was a retrieval inhibition effect rather than a memory editing strategy.

How do the current findings fit false memory theories? Although both AAT and FTT agree that the growth and restructuring of children's knowledge base is key to the increase of spontaneous production of false memories with age, so far, only AAT makes additional assumptions about the importance of the automaticity of associative activation in false memory and its development. The experiments presented here do not, therefore, test one theory against the other, but rather test a hypothesis generated from the assumptions of AAT. According to Wimmer and Howe (2009, 2010), when children produce false memories, they are generated from fairly automatic activation processes but this automaticity increases with age. Therefore increases in the encoding and generation of false memories involve both domain specific (growth and reorganization of knowledge base) and domain general (increased automaticity of processing) developments.

Together with previous findings, the results from this study suggest that the story is similar at the output stage. According to these findings there appears to be qualitative as well as quantitative developmental differences that occur after the critical lure is activated at study. We argue that, for children, the false item may enter their conscious awareness by becoming part of their episodic memory for that list. As the episodic list becomes intentionally suppressed by the directed-forgetting instruction, children's false memories will decline. Children are not intentionally suppressing false memories but rather, they are becoming consciously aware of the false item because it forms part of an episodic list. With age, false items begin to remain outside of conscious awareness, not becoming part of the episodic memory and thus, like adults, rendering older children unable to prevent the output of the unpresented critical lures during recall. Hence, although children's false memories are generated relatively automatically, the ability to access and output false memories during retrieval is still subject to conscious control.

References

Anderson, M. C., Bjork, R. A., & Bjork, E. L. (1994). Remembering can cause forgetting: Retrieval dynamics in long-term memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*, 1063-1087.

Basden, B. H., Basden, D. R., & Gargano, G. J. (1993). Directed forgetting in implicit and explicit memory tests: A comparison of methods. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19,* 603–616.

Bäuml, K.-H., & Kuhbandner, C. (2003). Retrieval-induced forgetting and part-list cuing in associatively structured lists. *Memory & Cognition*, *31*, 1188-1197.

Bjorklund, D. F. (1987). How changes in knowledge base contribute to the development of children's memory. *Developmental Review*, *7,* 93-130.

Bjorklund, D. F. (2005). *Children's thinking: Developmental and individual differences* (4th edition). Belmont, CA: Wadsworth/Thompson.

Bouwmeester, S., & Verkoeijen, P. J. L. (2010). Latent variable modelling of cognitive processes in true and false recognition of words: A developmental perspective. *Journal of Experimental Psychology: General, 139,* 365-381.

Brainerd, C. J., & Reyna, V. F. (2005). *The science of false memory*. NewYork: Oxford University Press.

Brainerd, C. J., Reyna, V. F., & Ceci, S. J. (2008). Developmental reversals in false memory: A review of data and theory. *Psychological Bulletin*, *134*, 343-382.

Brainerd, C. J., Reyna, V. F., Wright, R., & Mojardin, A. H. (2003). Recollection rejection: False-memory editing in children and adults. *Psychological Review*, *110*, 762-784.

Carneiro, P., & Fernandez, A. (2010). Age differences in the rejection of false memories: The effects of giving warning instructions and slowing the presentation rate. *Journal* *of Experimental Child Psychology, 105,* 81-97.

Carneiro, P., Fernandez, A., & Dias, A. R. (2009). The influence of theme identifiability on false memories: Evidence for age-dependent opposite effects. *Memory & Cognition, 37*, 115-129.

Coltheart, M. (1981). The MRC Psycholinguistic Database. *Quarterly Journal of Experimental Psychology, 33A,* 497-505.

Deese, J. (1959). On the prediction of occurrence of particular verbal intrusions in immediate recall. *Journal of Experimental Psychology*, *58*, 17-22.

Dewhurst, S. A., Bould, E., Knott, L. M., & Thorley, C. (2009). The roles of encoding and retrieval processes in associative and categorical memory illusions. *Journal of Memory and Language, 60,* 154-164.

Dodd, M. D., & McLeod, C. M. (2004). False recognition without intentional learning. *Psychonomic Bulletin & Review*, *11*, 137-142.

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for social, behavioural, and biomedical sciences. *Behavior Research Methods, 39,* 175-191.

Gallo, D. A., Roberts, M. J., & Seamon, J. G. (1997). Remembering words not presented in lists: Can we avoid creating false memories? *Psychonomic Bulletin & Review*, *4*, 271-276.

Ghetti, S. (2008). Rejection of false events in childhood: A metamemory account. *Current Directions in Psychological Science, 17,* 16–20.

Harnishfeger, K. K., & Pope, R. S. (1996). Intending to forget: The development of cognitive inhibition in directed forgetting, *Journal of Experimental Child Psychology, 62,* 292-315.

Howe, M. L. (2005). Children (but not adults) can inhibit false memories. *Psychological*

Science, 16, 927–931.

Howe, M. L. (2006). Developmentally invariant dissociations in children's true and false memories: Not all relatedness is created equal. *Child Development, 77,* 1112–1123.

Howe, M. L., Toth, S. L., & Cicchetti, D. (in press). Can maltreated children inhibit true and false memories for emotional information? *Child Development*.

Howe, M. L., Wimmer, M. C., Gagnon, N., & Plumpton, S. (2009). An associative activation theory of children's and adults' memory illusions. *Journal of Memory and Language*, *60*, 229-251.

Hutchison, K. A., & Balota, D. A. (2005). Decoupling semantic and associative information in false memories: Explorations with semantically ambiguous and unambiguous critical lures. *Journal of Memory and Language, 52,* 1–28.

Kimball, D. R., & Bjork, R. A. (2002). Influences of intentional and unintentional forgetting on false memories. *Journal of Experimental Psychology: General*, *131*, 116–130.

Lee, Y. (2008). Can intentional forgetting reduce false memory? Effects of list-level and item-level forgetting. *Acta Psychologica, 127,* 146-153.

Marche, T. A., Brainerd, C. J., Lane, D. G., & Loehr, J. D. (2005). Item method directed forgetting diminishes false memory. *Memory, 13,* 749-758.

Marsh, E. J., Dolan, P. O., Balota, D. A., & Roediger, H. L., III (2004). Part-list cuing in younger and older adults*, Psychology & Aging, 19,* 134-144.

Miller, E. K., & Cohen, J. D. (2001) An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience. 24,* 167–202.

Roediger, H. L., III, & McDermott, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*, 803-814.

Roediger, H. L., III, Watson, J. M., McDermott, K. B., & Gallo, D. A. (2001). Factors that determine false recall: A multiple regression analysis. *Psychonomic Bulletin & Review, 8*, 385-407.

Rundus, D. (1973). Negative effects of using list items as recall cues. *Journal of Verbal Learning and Verbal Behavior, 12*, 43-50.

Seamon, J. G., Luo, C. R., & Gallo, D. A. (1998). Creating false memories of words with or without recognition of list items: Evidence for nonconscious processes. *Psychological Science, 9*, 20-26.

Seamon, J. G., Luo, C. R., Shulman, E. P., Toner, S. K., & Caglar, S. (2002). False memories are hard to inhibit: Differential effects of direct forgetting on accurate and false recall in the DRM procedure. *Memory, 10*, 225-237.

Stadler, M.A., Roediger, H.L., & McDermott, K.B. (1999). Norms for word lists that create false memories. *Memory & Cognition, 27,* 494-500.

Stuart, M., Masterson, J., Dixon, M., & Quinlan, P. (1993-1996). Children's printed word database. Available from: http://www.essex.ac.uk/psychology/cpwd/.

Tomlinson, T. D., Huber, D. E., Rieth, C. A., & Davelaar, E. J. (2009) An interference account of cue-independent forgetting in the no-think paradigm, *Proceedings of the National Academy of Sciences of the United states of America, 106,* 15588-15593.

Underwood, B. J. (1965). False recognition produced by implicit verbal responses. *Journal of Experimental Psychology, 70,* 122-129.

Van Overschelde, J. P., Rawson, K. A., & Dunlosky, J. (2004). Category norms: An updated and expanded version of the Battig and Montague (1969) norms. *Journal of Memory and Language, 50,* 289-335.

Wimmer, M. C., & Howe, M. L. (2009). The development of automatic associative processes and children's false memories. *Journal of Experimental Child Psychology, 104*, 447-465.

Wimmer, M. C., & Howe, M. L. (2010). Are children's memory illusions created differently than adults'? Evidence from levels-of-processing and divided attention paradigms. *Journal of Experimental Child Psychology*, *107*, 31-49.

Zellner, M., & Bauml, K-H. (2005) Intact retrieval inhibition in children's episodic recall. *Memory & Cognition*, *33*, 396-404.

Appendix

DRM and category lists used in Experiment 1, Experiment 2, and Experiment 3

1. DRM lists (with BAS scores).

CL	Item	BAS	CL	Item	BAS
Cold	hot	.67	**Window**	door	.16
	shiver	.67		glass	.14
	freeze	.46		sill	.68
	chilly	.40		ledge	.15
	frost	.37		house	.00
	ice	.36		open	.01
	warm	.36		curtain	.19
	winter	.28		frame	.01
	snow	.20		view	.05
	weather	.03		shutter	.48
	Mean	.38		Mean	.19
Doctor	nurse	.55	**Foot**	toe	.61
	physician	.80		ankle	.36
	surgeon	.48		shoe	.32
	patient	.37		sandals	.21
	dentist	.21		sock	.17
	medicine	.15		hand	.16
	clinic	.30		knee	.03
	hospital	.03		boot	.14
	sick	.03		kick	.04
	ill	.00		arm	.00
	Mean	.29		Mean	.20
King	queen	.73	**Sleep**	nap	.73
	throne	.76		rest	.47
	crown	.47		tired	.49
	royal	.32		snooze	.52
	prince	.13		yawn	.24
	palace	.16		dream	.24
	monarch	.32		relax	.14
	george	.02		lazy	.06
	rule	.01		quiet	.02
	leader	.03		wake	.30
	Mean	.30		Mean	.29

Sweet	sour	.41	**Mountain**	hill	.43
	candy	.34		valley	.16
	sugar	.43		climb	.29
	bitter	.44		summit	.11
	honey	.45		climber	.60
	taste	.07		top	.00
	tooth	.00		glacier	.02
	soda	.00		steep	.06
	cake	.03		ski	.03
	chocolate	.10		high	.03
	Mean	.23		Mean	.17

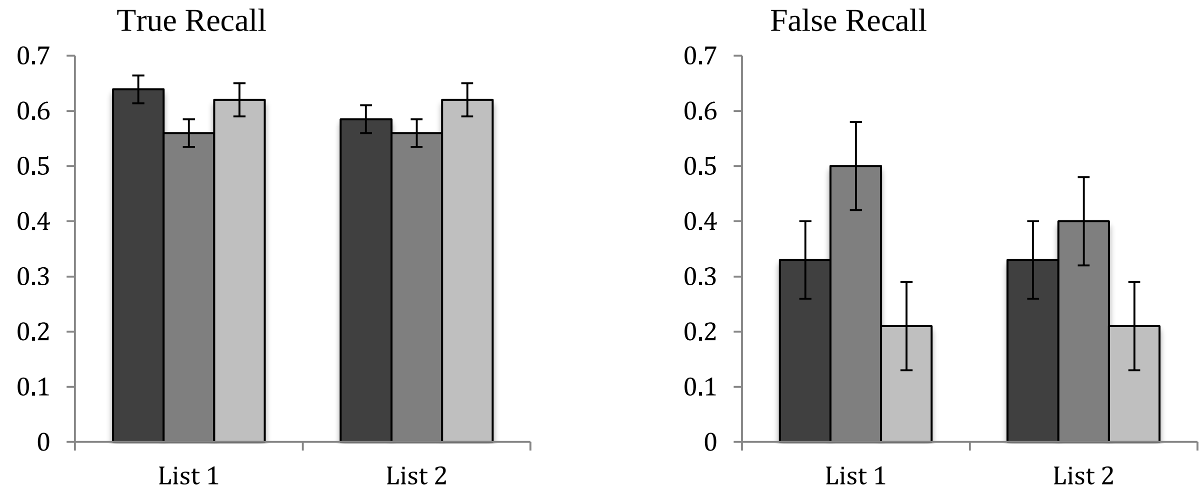
Appendix cont.

2. Category lists (with BAS scores).

CL	Item	BAS	CL	Item	BAS
Chair	table	.76	**Ant**	spider	.19
	couch	.29		moth	.11
	recliner	.55		mosquito	.05
	stool	.32		caterpillar	.03
	desk	.29		bee	.01
	sofa	.13		wasp	.02
	cabinet	.02		butterfly	.00
	bed	.00		cockroach	.00
	dresser	.00		ladybird	.00
	bookshelf	.00		beetle	.00
	Mean	.24		Mean	.04
Apple	pear	.25	**Football**	soccer	.13
	banana	.15		rugby	.04
	orange	.08		basketball	.04
	peach	.06		tennis	.01
	grape	.03		volleyball	.03
	plum	.05		hockey	.00
	kiwi	.00		swimming	.00
	strawberry	.00		golf	.00
	cherry	.08		skiing	.00
	lemon	.01		running	.00
	Mean	.07		Mean	.03
Hammer	nail	.62	**Robin**	sparrow	.05
	chisel	.41		pigeon	.02
	saw	.10		hawk	.00
	screwdriver	.08		eagle	.00
	wrench	.09		crow	.00
	screw	.03		hummingbird	.00
	drill	.00		parrot	.00
	sander	.00		duck	.00
	knife	.00		canary	.00
	wood	.00		owl	.00
	Mean	.13		Mean	.01

Car	van	.45	**Carrot**	celery	.21
	bus	.25		potato	.03
	truck	.26		cabbage	.01
	jeep	.30		turnip	.02
	taxi	.13		lettuce	.01
	motorcycle	.09		onion	.01
	bicycle	.04		leek	.01
	airplane	.03		sprouts	.00
	subway	.03		peas	.00
	boat	.00		broccoli	.00
	Mean	.16		Mean	.03

Adults



Children

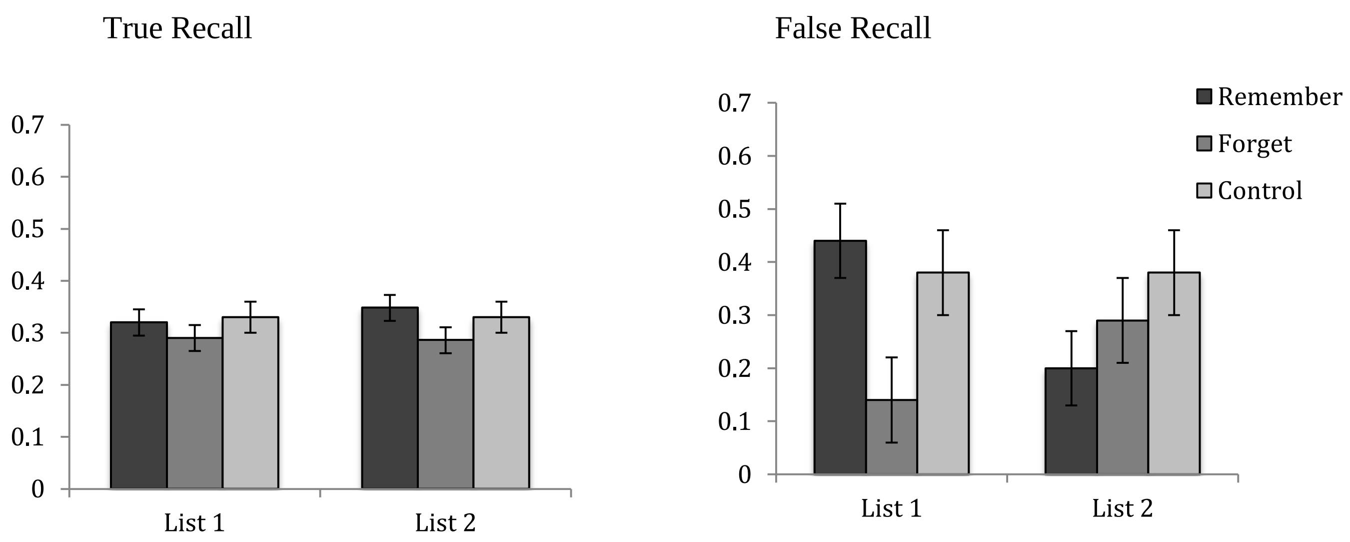
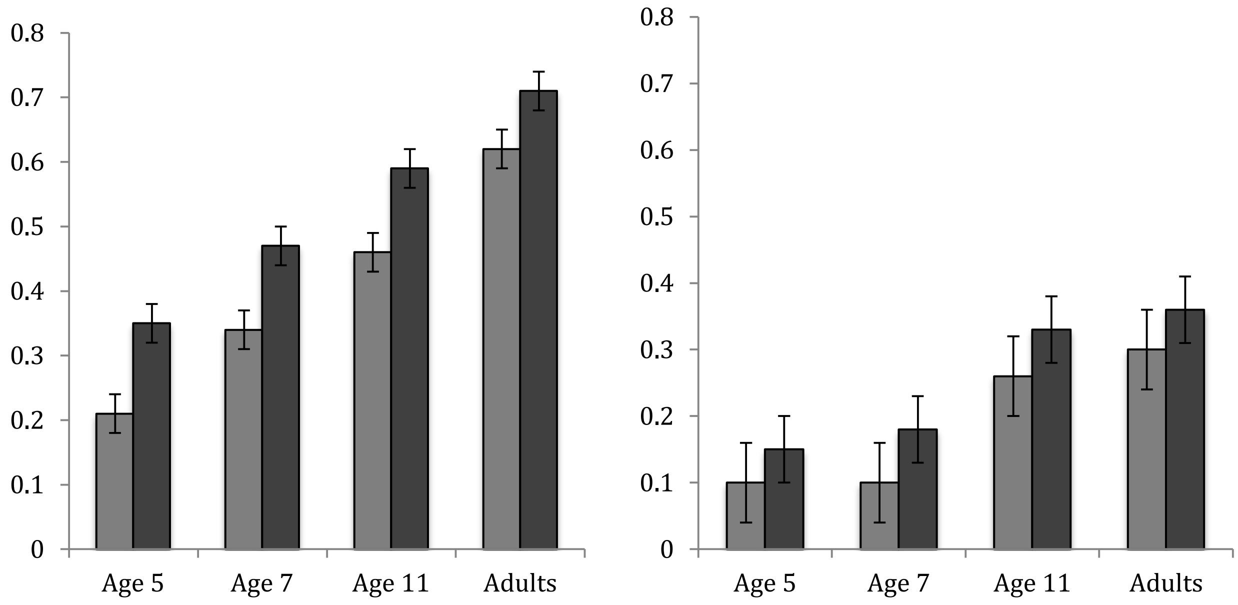


Figure 1. Children and adult's True and False recall for List 1 and List 2 in Experiment 1 (with standard error bars).

DRM lists

True recall

False recall



Category lists

True recall

False recall

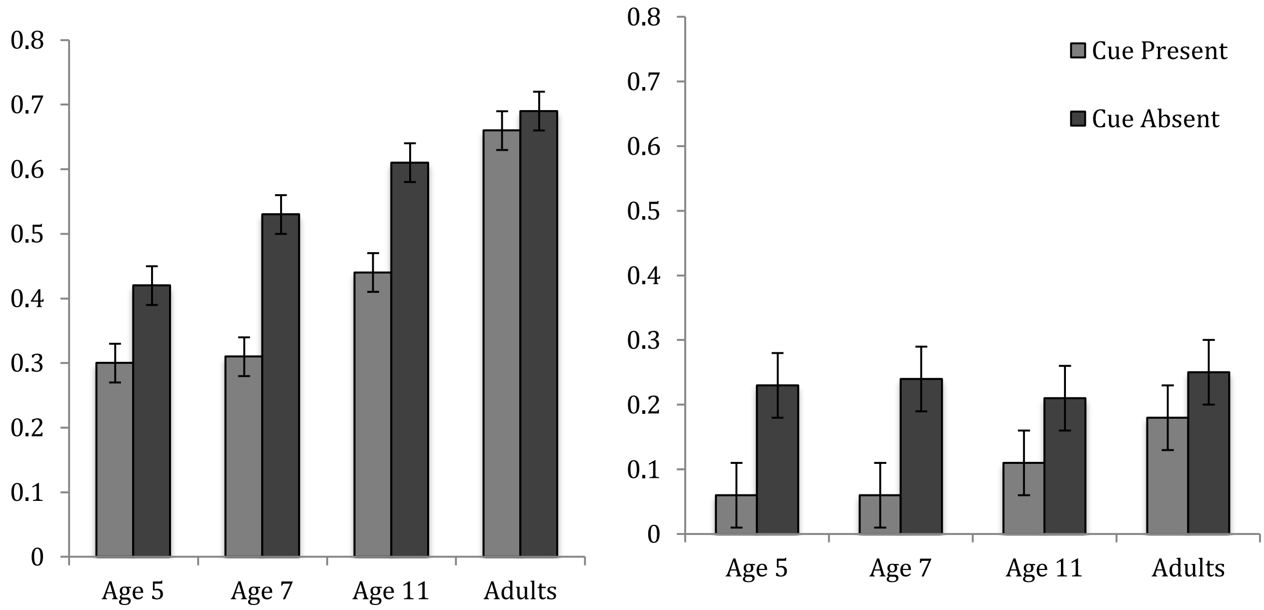


Figure 2. Recall for studied items and critical lures as a function of Age, Cue condition, and List Type for Experiment 2 (with standard error bars).

True recall

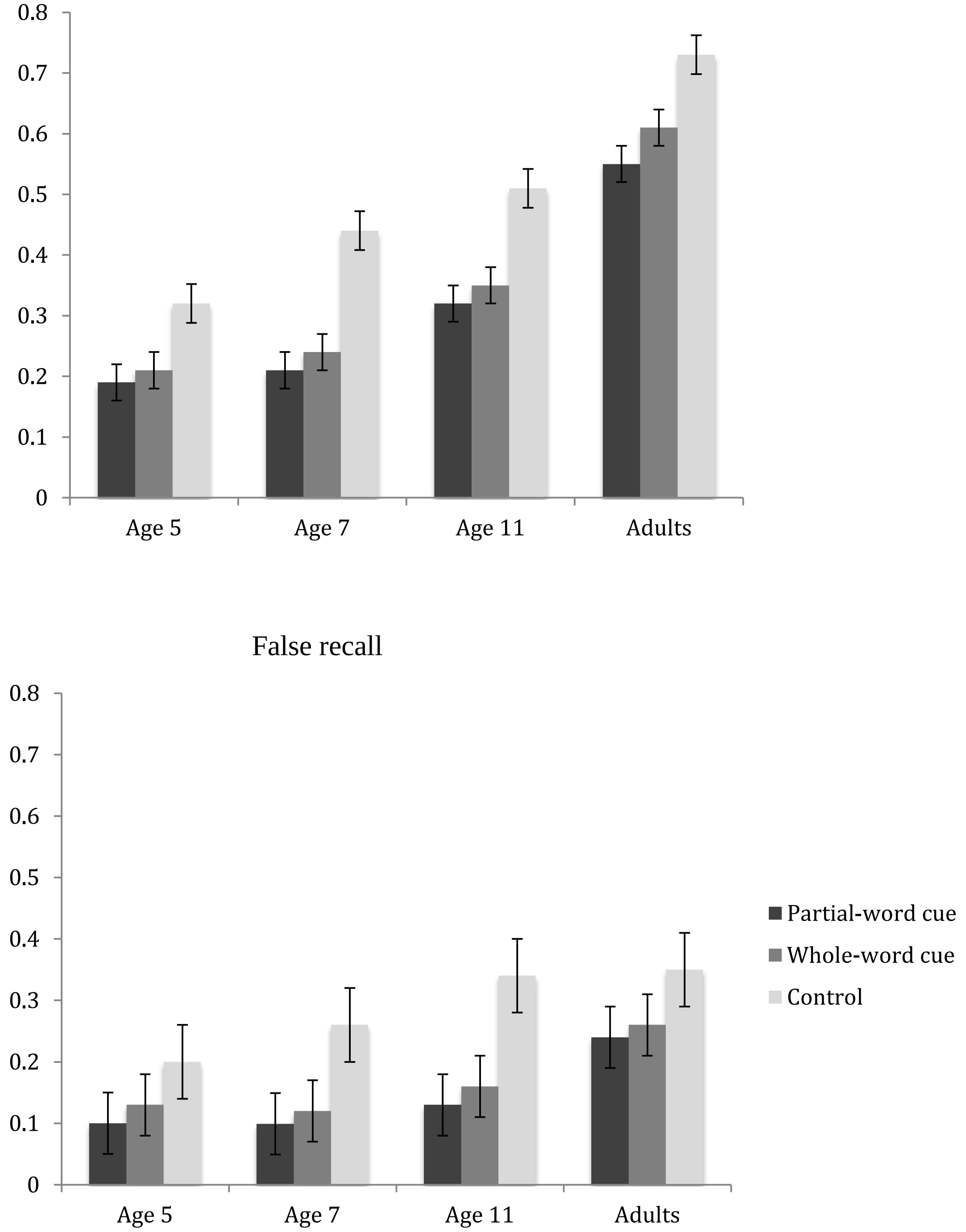


Figure 3. Recall for studied items and critical lures as a function of Age and Recall condition for Experiment 3 (with standard error bars).