BACKWARD AND FORWARD ASSOCIATIVE STRENGTH

Backward and Forward Associative Strength in Children's False Recall for DRM and Categorical Word Lists

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Abstract

Recent findings with children and adults propose that the developmental increase in the DRM false memory illusion is not related to children's increased ability to process relational meaning across list items as proposed by Fuzzy-trace theory (FTT). These studies show that the effects of semantic information are limited to true memories. Unlike the propositions of FTT, this suggests that false memories do not benefit from this type of information. Previous research with adults has demonstrated that the DRM false memory illusion using recall tasks is strongly related to DRM lists' backward associative strength (BAS). However, the role of lists' associative strength has not yet been examined on children's false recall. This study sought to examine the role of associative strength on children's false recall using the DRM paradigm and to further examine the role of semantic information on children's true and false memories. Children with the ages of 5, 7, and 11 years, studied and recalled 12 (6 DRM, 6 category) word lists with varying backward and forward associative strengths. To examine the role of semantic information, half of the children in each age group were provided with descriptive labels prior to list presentation. Results indicated that children's false recall of category and DRM lists were effected by different variations of associative strength, where the highest rates of false recall was obtained from DRM lists with high backward- high forward associative strength, and category lists with high backward-low forward associative strength. This also varied within each age group. Children's true and false recall benefited from descriptive labels. However, the increase in false memories can be attributed to the strong associative relations between the descriptive label and the critical lures of category lists. When associative relations between descriptive labels and critical lures were low, as

in DRM lists, there was no beneficiary effect of labels on false recall. These results suggests that as in adults, children's false memories occur as a result of associative activation, whether from backward or forward associative links with list items or descriptive labels. This is in line with false memory theories based on network models of semantic knowledge (such as activation/monitoring theory), where falsely reporting the critical lure within the DRM paradigm results from its activation through highly related list items. Children's increased susceptibility to the false memory illusion may be related to an increased automaticity in processing associative relations between list items and the lure rather than an increased ability to extract meaning across list items.

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Research on false memories has indicated that children are less susceptible than adults to the false memory illusion (Brainerd, Holliday, & Reyna, 2004; Brainerd, Reyna, & Forrest, 2002; Howe, Cicchetti, Toth, & Cerrito, 2004; Price, Metzger, Williams, Phelps, & Phelps, 2001). These findings have been reliable using the Deese-Roediger-McDermott (DRM) paradigm, a task which consists of presenting lists of words which are related to an unpresented concept (e. g., *hot, snow, warm, winter, ice, wet, frigid, chilly, heat, weather, freeze,* and *air* are related to the unpresented item COLD). The unpresented item, also termed the critical lure, is often reported along with presented list items during subsequent recall tasks. However, as previously mentioned, children are less likely to include the critical lure along with list items during recall, which in turn results in lower false memory rates as compared to adults.

A popular theoretical explanation of this effect argues that children's low susceptibility to the false memories illusion is related to their poor ability to extract relational meaning across list items. Accordingly, as children's ability to extract a list's thematic meaning increases with age, so does their susceptibility to report the critical lure along with list items during recall. Such a theoretical explanation is practical in that it can easily account for the developmental trend in children's false memory research. However, results with adults on the role of associative relations between list items and the critical lure are particularly difficult to explain by theories relying on meaning extraction. Unlike alternative theoretical explanation of the false memory illusion, theories based on meaning do not propose that associative relations between list items and the critical lure play a role in the production of false memories.

Earlier research with adults has proposed that the associative relations between list items and the critical lure are important contributors to the false memory illusion (Deese, 1959; McEvoy, et al., 1999; Roediger, Watson, McDermott, & Gallo, 2001). The strength of the associative links between list items and the critical lure, also termed backward associative strength (BAS), is indicative of a list's ability to produce false memories in adults, where lists with poor mean BAS yield low rates of false memories (Gallo & Roediger, 2002). Similarly, recent findings have indicated that the strength of associative links between the critical lure and the list items, also referred to as forward associative strength (FAS), can also influence the production of false recognition in adults (Brainerd & Wright, 2005). Therefore, contrary to the propositions of meaning-based theories, associative strength, whether forward or backward, appears to play an important role in adults' production of false memories.

Recent findings on the dissociation of true and false recall have also been particularly difficult to account for by theories relying on meaning extraction. As demonstrated by Hutchinson and Balota (2005), it appears that adult's rates of true and false memories are influenced by different factors, where within lists thematic relations are favorable to true memories, and associative relations to false memories. Furthermore, these effects are limited to their respective types of recall; that is, changes in thematic relations do not result in changes in rates of false memories, just as variations in associative strength do not result in changes in rates of true memories. Similar findings have also been reported with children (Howe, 2006). As in previous studies both true and false recall increased with age, but as in adult dissociation research, children's false memories were not influenced by increases in thematic relations between list items. Instead, this effect was limited to children's true recall. Furthermore, Howe (2006) also reported that children's false memory rates did not increase when cues describing the overall meaning of lists were provided prior to encoding. It appears that contrary to predictions from meaning-based theories, children's false memories do not increase when provided with thematic lists or descriptive cues enhancing a list's meaning. As in adults, the effects of this type of information are limited to true recall.

These findings are particularly interesting for theoretical explanations proposing that false memories result from associative priming of the critical lure through its associative links with list items. Although most of false memory research pertaining to this theoretical view has been limited to adults (such as the activation/monitoring theory), recent findings on children's dissociations suggests that the false memory developmental trend is related to the development of associative links between concepts rather than children's growing ability to extract meaning across list items. As proposed by memory organization research, associative links between concepts appear at a relatively young age, and are further strengthened and defined with increases in both knowledge and experience (Bjorklund, 1987; Frankel & Rollins, 1991). Thus, children's false memories, as in adults', should be particularly vulnerable to changes in associative strength. To date, no study has examined the role of associative strength on children's false memory production. In an attempt to further define the role of associative relations in the production of false memories this study examined the role of associative strength on children's true and false memories. A detailed description of the study will be provided following an overview of the literature pertaining to the role of associative priming in the context of false memory research.

Literature Review

History of False Memory Research

Early work on false memories can be traced back to popular psychologists such as Alfred Binet, Jean Piaget, and F. C. Bartlett, whose respective work on memory suggestibility, cognitive development, and memory for meaningful materials paved the path to research on the production of false memories (for a review, see Brainerd & Reyna, 2005). However, the beginnings of false memory research using word lists are more appropriately attributed to James Deese, whose research focused on the factors influencing adults' elicitation of related but non-studied items during recall tasks.

Deese (1959) examined adult's recall for word lists composed of items highly related to an unpresented concept. His two-fold study consisted of encoding and recalling 36 12-item lists and, free association tasks using the list items. In the first part of the study, the lists studied by participants were composed of the 12 highest frequency word responses generated for a target word in the Kent-Rosanoff word association lists (e.g., *hot, snow, warm, winter, ice, wet, frigid, chilly, heat, weather, freeze,* and *air* were the 12 most frequent items generated as a response to the word *cold*). Inclusion of this related but unpresented word (e.g. *Cold*) during free recall following list presentation consisted of a false memory. In the second part of the study, the list items (*hot, snow, etc.*) were used as stimuli in free association tasks with different participants. Responses to each item were collected across participants and the frequency of each response was measured. Due to the list items strong associations to their respective critical lures, they were inadvertently included as responses to list items. The frequency of inclusion of the critical lures as a response to list items was then tallied across participants. The response frequency count of the critical lure enabled Deese (1959) to determine the strength of the associative relations between the list items and their respective target; this was also referred to as backward associative strength, (BAS).

Results from the free recall task demonstrated that although lists were constructed in a similar fashion participant's tendency to include the target item during free recall greatly varied across lists. To further investigate this finding, Deese (1959) examined the relation between false memories and BAS and found that the occurrence of false memories was in fact highly related to the associative relations between items and the critical lure ($r = .87$). Thus, although constructed the same, lists with strong BAS produced higher rates of intrusions during free recall than lists with weaker backward associative links. These findings were later extended in Underwood's (1965) study on implicit associative responses (IAR). Unlike Deese (1959) who proposed that the activation of associative links between list items and the critical lure occurred at remembering, Underwood (1965) proposed that the elicitation of related targets through their associative relations with other items occurred during presentation of the list items.

Underwood (1965) examined associative priming in adults for various types of associative relations using an extensive word lists composed of various associates and an old/new recognition task. In order to determine if an item was unconsciously activated by the earlier presentation of an associated item, participants were required to judge whether each word had previously been heard. The results indicated that subjects were more likely to judge an item as 'old' if it had previously been activated by a critical stimulus word.

More specifically, false recognition was more likely for converging associates (e.g.: butter-bread), antonyms (e.g.: false-true), and superordinates (e. g.: maple-tree). As demonstrated by the results of these earlier studies, adults' activation of associative links between related concepts can be particularly strong for highly associated items. In fact, this associative priming can be strong enough to lead adults to erroneously believe that unpresented but associated items were also experienced.

Re-emergence of False Memory Studies

Following the emergence of high profile court cases on false accusations of child sexual abuse (Sauer, 1993) and clinical research on recovered memories in the early to mid- 1990s (see Loftus, Garry, & Feldman, 1994; Williams, 1994), false memory research using word lists re-appeared in the field of cognitive research. Deese's research on false memories using associative lists was revived when Roediger and McDermott (1995) replicated his earlier findings and enlarged the list repertoire by adding 24 new lists each composed of 15 items. Construction of the new lists was completed using the same method and again, similar variations in intrusion rates were found by testing these new lists. A new facet was also added to the DRM list presentation: a recognition task comparable to Underwood's (1965) work. Unlike recall, this task was introduced following the presentation of all lists. Later, more lists were developed and recall and recognition norms were generated for each 36 DRM list using undergraduate students (Stadler, Roediger, & McDermott, 1999). Variation in rates of false recall and recognition were again noted across lists, with a range of 10%-65% for false recall and 27%-84% for false recognition (Stadler et al., 1999).

Although a number of theoretical explanations of false memories have focused on associative priming, others, such as Fuzzy-trace theory, have proposed that false memories are a result of meaning extraction. Previous results from studies with adults have leaned towards both explanations. Until recently, theoretical explanations relying on meaning extraction best accounted for the findings of studies with children. However, as demonstrated by Howe (2006), associative theories may be better suited as an explanation of children's false memories.

Theoretical Explanations

As previously mentioned, research with adults using the DRM paradigm has demonstrated that the frequency of falsely remembering an unpresented item is highly reliable (Roediger & McDermott, 1995; Stadler et al., 1999). Although the frequency of occurrence varies across lists, the DRM false memory illusion is persistent in adults using either or both free recall and recognition tasks. Young children, unlike adults, are less likely to succumb to the DRM false memory illusion. More specifically, it appears that as children get older they become more susceptible to false memories. In order to understand children's low rates of false memories, theoretical explanations focusing on the development of specific cognitive functions and their role in the developmental variability of the false memory illusion will be considered.

Fuzzy-trace Theory

Originally developed as a model of reasoning and decision making, fuzzy-trace theory (FTT) is now a popular theoretical explanation of the DRM false memory illusion. Applied to a list learning paradigm, this theory proposes that two types of memory traces, verbatim and gist, are simultaneously stored upon presentation of each item (for a review see Brainerd & Reyna, 2005). Item-specific information pertaining to surface details, such as the speaker's voice or word length, are characteristics encoded by verbatim traces. Gist traces, on the other hand represent meaning-based interpretations extracted across the list items, capturing the overall theme of word lists. According to FTT both memory traces contribute to memory performance. However, their roles in remembering studied items depend on their inherently different characteristics.

According to FTT, memory performance in the DRM paradigm is influenced by the information provided by both verbatim and gist traces. For instance, items for which both traces are consistent and available will inevitably be correctly recalled. Correct recall of list items can also occur in instances where only one type of trace is available. For example, remembering item-specific details (verbatim) of an item would ensure true recall for that given item. This may not be the case when verbatim traces are unavailable for some items. Verbatim traces, unlike gist traces, fade quickly over time, limiting their quality and accessibility to guide true recall. Although sole reliance on gist traces can lead to correct recall, it also results in incorrectly endorsing unpresented but meaning-consistent items such as the critical lure in the DRM paradigm.

The occurrence of false memories in children will depend on their ability to store, retrieve, and preserve both verbatim and gist traces (Brainerd & Reyna, 2005). However, FTT proposes that the developmental paths of verbatim and gist traces are not parallel. Due to its complexity, children's ability to extract gist across list items is slower to develop as compared to processing and encoding item-specific details. As a result, young children's ability to extract relational meaning across list items is especially poor, leaving them less susceptible to the false memory illusion. Therefore, even though children are able to process information from an individual list item, their ability to extract relational meaning across these items is limited (Brainerd & Reyna, 2004). As their cognitive processing abilities continue to develop, children's true and false memories will increase with age.

Fuzzy-trace theory is appealing in that it can account for the developmental trend in DRM false memory research without considering the role of associative relations. Children's rates of false recall are a reflection of their abilities to process gist information across list items. However, recent findings have demonstrated that children's false memories may not be related to their ability to process meaning across lists of words (e.g. Howe, 2006). Furthermore, it appears that as in adults, the effects of thematic information are limited to true recall and not, as FTT proposes, to false recall. Prior to the discussion of false memory studies on associative priming, research on the development of memory organization will be considered.

Children's use and development of conceptual relations. Previous research on the development of memory organization has determined that associative relations between concepts are established at a very young age in children. It has also been established that these early associative representations remain relatively unchanged throughout life (Lange, 1978). Research on the development of conceptual organization in memory has indicated that both younger and older children rely on associative links between concepts to guide recall, but that the additional use of categorical information along with associative relations is limited to older children (Bjorklund & de Marchena, 1984, Bjorklund & Jacobs, 1985). With development children gain more experience and knowledge and their ability to extract and use categorical relations along with associative relations to guide recall subsequently improves (Bjorklund, 1987). However, given that conditions are made favourable, even young children will use categorical relations. Increasing the saliency of categorical information by blocking similar category items together can facilitate the processing of such relations for young children (Howe, Brainerd, Kingma, 1985). Although associative relations between concepts appear to develop earlier in life than categorical relations, children's ability to efficiently process categorical relations can be facilitated by blocking category exemplars and by providing category items with inherently strong associative links. As mentioned in Hutchinson (2003), items in category word lists are not devoid of associative relations.

Children's slower progress to process categorical information as compared to their ease in processing associative relations may be related to the inherent structure of categorical relations. Unlike associative relations, categorical relations are also marked by taxonomic structure, where schematically organized knowledge becomes more and more taxonomically (semantically) structured as children gain more experience and knowledge (for a review, see Blewitt & Toppino, 1991). Furthermore, as demonstrated by Blewitt and Toppino (1991), certain taxonomic relations appear relatively early in children. More specifically, these researchers found that superordinate (e.g., animal-elephant) and schematic structure (e.g., zoo-elephant) are established early and does not seem to change with age. Thus, it appears that children's organization of related concepts begins at an early age, where structured relations between related concepts become better defined with increasing knowledge and experience.

Current findings on children's false memories has demonstrated that young children, like older children and adults, are capable of spontaneously extracting categorical relations across lists of words. Recent work by Howe (2006, Experiment 2) has shown that children as young as 5-years old can use categorical relations from blocked category lists using the DRM paradigm. In this study, young children's rates of true and false recall were not influenced by the provision of superordinate category cues prior to list presentation. Despite their ability to spontaneously extract the thematic relationship across lists' items, young children's rates of true and false recall remained lower than that of older children and adults', undermining FTT's predictions on the development of false memories. That is, unlike FTT's assumptions, providing gist-consistent descriptive cues did not increase children's false recall. Therefore, it appears that children's abilities to extract meaning across word lists are unrelated to their low susceptibility to the false memory illusion. Instead, as proposed by theories relying on associative priming, children's false memories, as adults', result from the activation of associative relations between list items and the critical lure.

Theories of Association

Associative theories, such as the activation/monitoring theory (see Roediger & McDermott, 1995; Roediger, et al., 2001), propose that false memories result from the activation of the critical lure through its associative relations with the list items. According to this theory, unpresented but related concepts, such as the critical lure, are activated by a spreading activation through associative links during the presentation of list items. This spreading activation primes the critical lure along with presented list items, making it equally, and in some cases more so, activated than presented list items. When highly activated the critical lure becomes difficult to distinguish from presented list items and increases the probability of it being reported as a presented item. Although this associative activation of the critical lure can result from automatic processing of associative relations between related concepts (as in Underwood's IAR, 1965), it can also result from elaborative processing of the associative links between list items and the unpresented but related items. As will be discussed below, the strength of the associative links between the list items and the critical lure is an important factor in determining the activation of the critical lure and the probability that it will be recalled along with list items.

The role of associative strength and direction. The role of associative strength in the production of false memories has mostly focused on the influence of lists items' backward associative links to the critical lure. Similarly, most research on the effects of associative strength has been limited to adults.

As predicted by Deese (1959), levels of BAS differentially affect the production of false memories, where high BAS is related to a high incidence of critical lures during free recall and low BAS to a low probability of false recall. In a multiple regression analysis examining 7 factors (word length, word frequency, word concreteness, BAS, FAS, connectivity, and true recall) influencing the differential rates of false recall across DRM lists, Roediger et al. (2001) found that backward associative strength was the strongest predictor of false memories ($r = .73$, $\beta = .70$). Unlike backward associative strength, lists' forward associative strength (FAS), the relation between the lure and the list item, was not significantly associated ($r = .08$, $\beta = .12$) with the production of false memories during free recall. A similar relationship between false recall and BAS was also found by McEvoy, Nelson and Komatsu (1999), where lists (constructed in a similar fashion than DRM lists) with high BAS elicited more false memories during free recall than lists with low BAS. Likewise, Gallo and Roediger (2002) found that when lists were constructed as in Deese (1959) using weak associates to the critical lure (thus reducing backward associative strength), resulting rates of false recall were also low. From these findings it appears that the strength of the associative relations between list items and the critical lure is directly proportional to the resulting rates of false recall in adults, where strong associative links result in high rates of false memories, and poor associative link to low rates of false memories.

Studies with adults have indicated that variations in lists' total, rather than mean, backward associative strength can directly influence the occurrence of false memories in the DRM paradigm (Robinson & Roediger, 1997). More specifically, Robinson and Roediger (1997) found that false recall increases in parallel with the addition of related items to increase both list length and total associative strength. On the other hand, adding unrelated associates to keep list length constant did not change rates of false recall, but rather was limited to decreasing rates of true recall. Given these results, it appears that a list's total, rather than mean, backward associative strength, influences false recall. Veridical recall, on the other hand, is diminished when unrelated unassociated exemplars disturb the semantic coherence of a list. Again, the effects of associative relations between list items and the critical lure appear to be limited to false memories.

Current research on source attribution has also indicated that strong backward association is highly related to the production of false memories (Hicks & Hancock, 2002; Hicks & Starns, 2006). More specifically, the results of these studies have indicated that attributes of the lists' strongest associates are also applied to the critical lure. By varying the gender of the speakers for items with strong and weak backward associative links to the critical lure, these studies have demonstrated that critical lures are not only elicited by the strongest associated items but that the gender characteristics of the source for these items were also attributed to the critical lure. Unlike the predictions of FTT, the findings of the previously mentioned studies clearly demonstrate that adult's false memories are a result the activation of the critical lure through its backward associative links with list items. Although forward associative links, associative relations between the lure and the items, have typically been dismissed, a recent study with adults has indicated that this may be related to their limited range in associative strength as compared to that of backward associative relations.

Previous studies examining the influence of many factors on false recall have failed to find a significant relationship between the FAS and false memories (see McEvoy et al., 1999; Roediger et al., 2001). However, recent findings have indicated that, when manipulated within lists and with its limited range in mind, mean forward associative strength (MFAS) could also influence the production of false memories in adults. Using eight 4-item lists with varying backward and forward associative strength, Brainerd and Wright (2005) found that lists with high forward or backward associative strength produced higher proportions of false recognition. More specifically, lists where either or both forward and backward associative strength was high produced the highest proportions of false recognition. It appears that, unlike previous findings, adult's false memories can also be influenced by the lures associative links to the list items.

As can be deducted from the results of these studies, the effects of associative strength appear to be limited to the production of false recall, whereas true recall appears to be uninfluenced by the strength or direction of associative links between list items and the critical lure and rather by a list's semantic consistency. This dissociation between true and false memories has recently been supported with adults and children, where thematic coherence of word lists was found to solely influence rates of true recall (Hutchinson & Balota, 2005; Howe, 2006). Similar to findings by Robinson and Roediger (1997), Hutchinson and Balota (2005) found that increasing the number of meaning-consistent items in word lists increased accurate recall without effecting rates of false memories. This was also found with children, where the presentation of category lists, as compared to that of associative (DRM) lists, resulted in increased rates of true recall (Howe, 2006). As in adults, children's false memories were unaffected by thematic information. Thus, contrary to the assumptions of FTT, it appears that children's false memories may be influenced by similar factors as adults. As will be discussed below, children's false memories, as in adults', also decrease when item presentation modalities are manipulated.

Although children's false memories are marked by their developing abilities to process different types of information (e.g. Dewhurst & Robinson, 2004), it is likely that due their early use of associative relations, their false memories, like those of adults, are also influenced by associative processing. While the previously mentioned studies with adults manipulated associative processing by decreasing or increasing a list's total or mean backward associative strength, other studies manipulating the mode of item presentation have also illustrated the role of associative processing in the production of false memories. Presenting list items through the use of pictures instead of oral presentation decreases rates of false memories for both children and adults since it provides additive distinctive information for list items as compared to the critical lure (Hege & Dodson, 2004; Ghetti, Qin, & Goodman, 2002). This effect was currently replicated with children in Howe (2006, Experiment 3) where rates of false recall did not increase with age when category list items were presented using pictorial stimuli. Thus, when associative processing is decreased due to the encoding of item-specific information, the typical developmental trend for false recall is eliminated for both category and DRM lists. These results from Howe (2006) are currently the only findings delineating the role of associative processing in children's false memories.

Theories of associations and developmental trends. According to associative theories, it is expected that children's false memories, like those of adults, should increase as a result of strong associative relations between list items and the critical lure. However, it is unlikely that young children's rates of false memories will be similar to those of older children and adults since the associative relations between their conceptual representations are not as well defined as adults. As demonstrated by studies of memory organization, the quantity and quality of links between old and newly acquired concepts continue to undergo significant changes with development (Bjorklund, 1987). As children gain knowledge and experience through development, their conceptual representations and their associative links with related concepts become better integrated in memory (Bjorklund, 1987). Although these changes in the organization of conceptual representations strengthen the links between related concepts, children's ability to process these relations and activate related concepts will also depend on their developing cognitive abilities.

The production of false memories in the DRM paradigm is relatively automatic for adults, where associated but unpresented items, such as the critical lure, are primed through their associative links with the presented list items. Children's ability to process and activate these items through their associative links with list items is not as automatic (for a review, see Howe, 2000). The activation of these associative links is effortful for young children, where the critical lure, as a result of conscious processing, is treated as having actually occurred (Howe, 2005). The development of organization of conceptual representations in memory does facilitate the activation of the critical lure, however; the parallel cognitive development also plays a role in increasing the automaticity with which related items are activated. As children get older, they require less cognitive effort to process and activate associative links between related concepts, which in turn increases their susceptibility to the DRM false memory illusion.

Although smaller in proportions, it appears that similar factors affect children and adults' true and false memories (Howe, 2006). Particularly difficult to account for by FTT is the lack of effect of descriptive labels on children's false recall for category lists (Howe, 2006). Although the use of category labels was manipulated to explore the role of gist-like information on children's false memories, research with adults has demonstrated that the use of category labels within the DRM paradigm using category lists can affect the items reported during recall. In their experiment Smith, Ward, Tindell, Sifonis, and Wilkenfeld (2000) found that the inclusion of related but unpresented items (critical lures, as well as semantically related items) was correlated ($r = .72$) with output dominance, where output dominance relates to the frequency to which an item is elicited as a response to the category label during the production of category norms (Smith et al., 2000; Barsalou, 1985). It appears that, for this study, the relations between the top exemplars of category lists and the category cue used during the production of category norms may be guiding the production of adult's false memories. Although this was not the case with previous research (Howe, 2006), we know from Frankel and Rollins (1991) that young children do use superordinate relations in categories. Providing a category label to children prior to presentation as in Howe (2006) could prime associates of the category, especially if strong associative links exists between the superordinate category label and the items on the category list. As stated by Hutchinson (2003), although categorical norms (from which category lists are derived) are often seen as purely semantic, they are not devoid of associative relations.

Associative strength is suspected to play an important role in the production of adult's false memories, but to date it has not yet been directly examined in children. As it has been illustrated by the above-mentioned studies, the DRM developmental trend may be more so related to the development of automaticity in associative priming rather than an inability to extract gist across list items. As demonstrated by Howe (2006), this lack of automaticity in priming associative relations appears to be the only factor differentiating children from adults. Like adults, the effects of thematic information appear to be limited to children's true memories, without influencing the rates of false memories. In an attempt to extent recent findings by Howe (2006), this study will examine the role of associative strength on children's true and false recall.

Present study

The previous findings from Howe (2006) on the dissociation of true and false memories in children emphasized the role of thematic information on true recall. More importantly, this was demonstrated by manipulating categorical and associative relations between-subjects. To further examine this dissociation, this study examined this effect within-subject. Thus, both category and associative (DRM) lists were studied by participants. It was expected that as in Howe (2006), children's true memories would be higher for category than for DRM lists; however, false memories in this study would vary for DRM lists due to differences in associative strength.

As indicated by studies with adults, false memories appear to vary as a result of strong associative links between list items and the critical lure (BAS). However, to date, the role of backward associative strength on the production of false memories has never been examined. As proposed by associative theories, false memories should increase when the critical lure is repeatedly activated through its strong associative relations with the list items. Whether this also applies for young children is unknown. As stated by Bjorklund (1987), although associative relations appear early in life, their quality and quantity will become better established as children gain knowledge and experience. By varying both forward and backward associative strength in category and DRM lists, this study examined the role of strong associative relations in the production of children's false memories. Although it was expected that older children would falsely recall more critical lures than young children, variations in associative strength for DRM lists should nonetheless influence false recall for each age group. More specifically, it was expected that lists with strong backward associative strength would yield higher rates of false recall than lists with lower backward associative strength. Due to DRM lists' stronger associative links, false recall for DRM lists should be greater than that for category lists.

Third, this study examined the role of forward associative strength on children's true and false recall. As previously mentioned, previous studies using free recall and DRM lists with adults did not find that forward associative strength contributed to the production of false memories. However, a recent study using recognition instead of recall has argued that this effect, or lack thereof, may be related to the limited range of forward associative strength for DRM lists as compared to backward associative strength. Indeed, by manipulating both mean backward and forward associative strength within lists, Brainerd and Wright (2005) found that both strong backward and forward associative strength could influence adult's false recognition. Whether this effect holds for children's recall was explored in this study by varying backward and forward associative strength within category and DRM lists. Although this factor was purely exploratory, it was nonetheless expected that forward associative strength may influence rates of false memories. However, this would be limited to cases where descriptive labels were provided.

Finally, as an extension to Howe (2006), children's use of descriptive labels for both category and DRM lists was explored between-subjects. Descriptive labels in Howe (2006) were used to demonstrate that, unlike the assumptions of FTT, even young children could process semantic information across list items. Although the descriptive labels in Howe (2006) failed to increase rates of true and false recall, results from research with adults has indicated that for category lists, output frequency of the list items during the production of category norms did influence rates of false recall when a descriptive cue was provided (Smith et al., 2000). Thus, although it was expected that young children are capable of extracting gist across list items, descriptive labels of category lists, through their forward associative links to the critical lure, may be more effective in priming their list's top category exemplars. Due to the use of the top exemplar as the critical lure for category lists, false memories rates may be higher for children provided with descriptive labels. This effect was also expected for DRM lists.

More specifically, it was expected that descriptive labels would prime the DRM list items as well as the critical lure in instances where backward associative links to the critical lure were weak.

In summary, the goal of this study was to further determine the role of associative strength on children's false memories. Although it was expected that the developmental trend would remain for both true and false recall, variations in a list's ability to induce false memories as a result of increased associative strength was anticipated for each age group. In order to examine the differential effects of associative and categorical relations on true and false memories, analyses of the results for true and false recall was considered separately. Such organization of the results has typically been found in false memory research.

Method

Participants

A total sample of 250 children were recruited from local schools, with 86 children from kindergarten (5-year-old; $M = 5.5$), 80 from Grade 2 (7-year-olds; $M = 7.6$), and 84 from Grade 6 (11-year-olds; $M = 11.5$). Participation was dependent on obtaining parental consent sought through a letter of permission. Children's assent to participation was determined by the experimenter on the day of testing.

Design, materials, and procedure

A 2 (List: DRM vs. Category) x 3 (Strength: High BAS-High FAS, High BAS-Low FAS, Low BAS-High FAS) x 3 (Age: 5 year-olds vs. 7 year-olds, vs. 11 year-olds) x 2 (Labels: No label vs. label) design was used where list and associative strength were manipulated within-subject and age and labels were manipulated between-subjects.

A total of twelve 14-item lists (6 DRM lists and 6 category lists) were presented to each child (see Appendix). Associative strength varied between these lists with each participant being exposed to 2 High BAS-High FAS DRM lists, 2 High BAS-Low FAS DRM lists, and 2 Low BAS-High FAS DRM lists. Similar variations in associative strength and direction were also found for the 6 category lists. List items were read aloud by the experimenter at a 3-second rate. Descriptive labels were manipulated between-subjects for both list types, where half of the participating children within each age group were provided with a descriptive cue prior to the presentation of each list. Descriptive labels for category lists consisted of the respective category name included in the norms, whereas labels for DRM lists were constructed to highlight the semantic relations shared across list items. Both DRM lists (drawn from Roediger et al., 2001) and category lists (drawn from van Overschelde, Rawson, & Dunlosky, 2004) have previously been used with children in these age groups (Brainerd et al., 2004; Howe, 2006; Seamon, Luo, Schlegel, Greene, & Goldenberg, 2000).

As in previous studies, the critical lure for category lists consisted of the highest frequency word for the selected category. DRM and category lists were selected on the basis of mean backward and forward associative strength gathered from the University of South Florida norms (Nelson, McEvoy, & Schreiber, 1999). In instances where associative strength was not available, the Edinburgh Associative Thesaurus (EAT) was consulted (Kiss, Armstrong, Milroy, & Piper, 1973). DRM lists were also selected on the basis of mean backward and forward associative strength which were gathered from Roediger et al. (2001). Mean forward and backward associative strength for DRM and category lists are shown in the Table 1.

In the event that words occurred in more than one list, the 15th item on the DRM lists (the next item for the category lists) was selected depending on the associative strength of the word in question (as in Gallo & Roediger, 2002). Words with the highest associative strength were kept, whereas words with lower contributions to the mean list associative strength were discarded.

DRM labels were constructed for the between-subject manipulation. Similar to Howe (2006), descriptive labels were included to ensure that children extracted the overall theme from the lists. Although they served the same purpose, labels for category and DRM lists differed in their semantic relation to the list's items. Due to inherent differences in the construction of DRM and category lists, labels for category lists represented the category membership of the lists (e.g.: Fruits, Insects, etc.), whereas labels for DRM lists depicted the underlying relationship between the list items and the critical lure (e.g.: Medical Things for the DOCTOR list). Items, on the other hand, were responses to category themes for category lists and words generating the critical lure for DRM lists.

Participants were randomly assigned to the label and no-label conditions, with half of the participating children in each age group assigned to the label condition. Prior to the presentation of the first list, general memory instructions were given by the experimenter. Children were instructed that they should pay careful attention to the list items as a subsequent recall task would follow each list. Following these instructions, children in the label condition received a label describing the theme of the list prior to the presentation of the items. Children in the no-label condition were given the list immediately. Following the presentation of the last list item, children engaged in a

Table 1

Mean backward and forward associative strength for each variation of category and DRM lists

	Category		DRM	
Associative Strength	MBAS	MFAS	MBAS	MFAS
High BAS-High FAS	.150	.040	.234	.062
High BAS-Low FAS	.080	.020	.235	.028
Low BAS-High FAS	.070	.030	.010	.061

Note. BAS = backward associative strength; FAS = forward associative strength; MBAS = mean backward associative strength of a list; MFAS = mean forward associative strength of a list.

distractor task (circling pairs of letters) for approximately 30 seconds. The free recall task followed during which the experimenter noted all recalled items. This procedure was repeated for the remaining 11 lists. List order was randomized within each age group.

Analytic Method

Results were analyzed using SPSS General Linear Model (GLM) Repeated Measures. Due to unequal groups, unweighted means were reported instead of descriptive means. Main effects were analyzed using Fisher's LSD; $p < .05$. Significant interactions were further explored using simple main effect analyses. This procedure was carried out for both true and false recall.

Results

Preliminary analyses did not reveal effects of gender and therefore it was eliminated from subsequent analyses. Mean proportion of items and critical lures recalled for both DRM and category lists with and without labels are illustrated in Figure 1 and 2, respectively. In accordance with the hypotheses for this study, rates of true and false recall will be analyzed separately, with the analyses for true recall preceding those of false recall.

True Recall

The proportion of items correctly recalled were analyzed using a 2(List: DRM vs. category) x 3(Strength: High BAS-High FAS vs. High BAS-Low FAS vs. Low BAS-High FAS) x 3(Age: 5-year-olds vs. 7-year-olds vs. 11-year-olds) x 2(Label: No label vs. label) mixed ANOVA, where list and strength were manipulated within-subject and age and label were manipulated between-subjects. The analyses revealed main effects of list, $F(1, 244) = 343.61, p < .001$, partial $\eta^2 = .585$, where fewer items were correctly recalled

Figure 1. Children's true recall of standard DRM and category word list without (Panel A) and with (Panel B) descriptive labels.

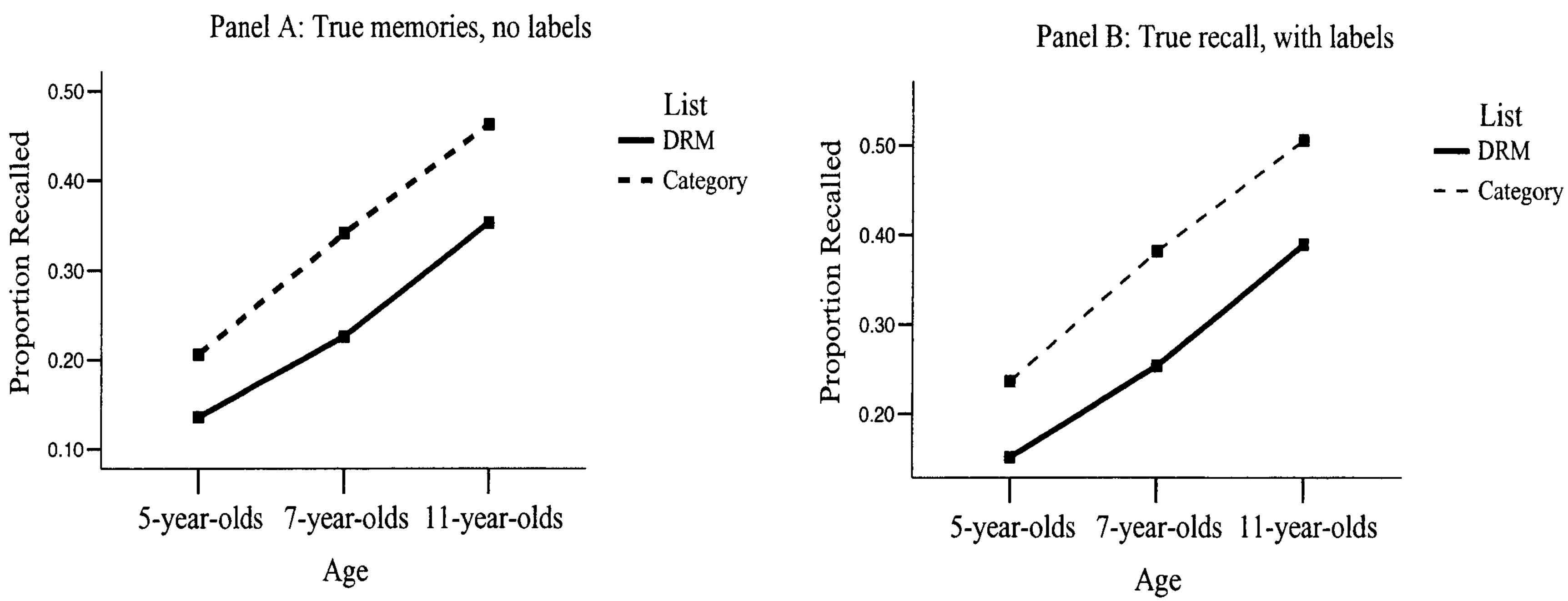
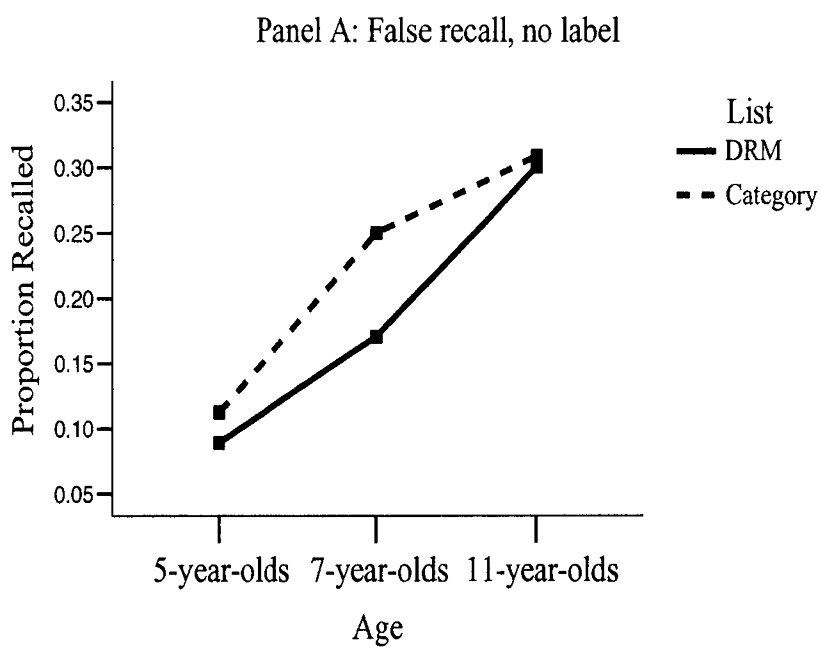
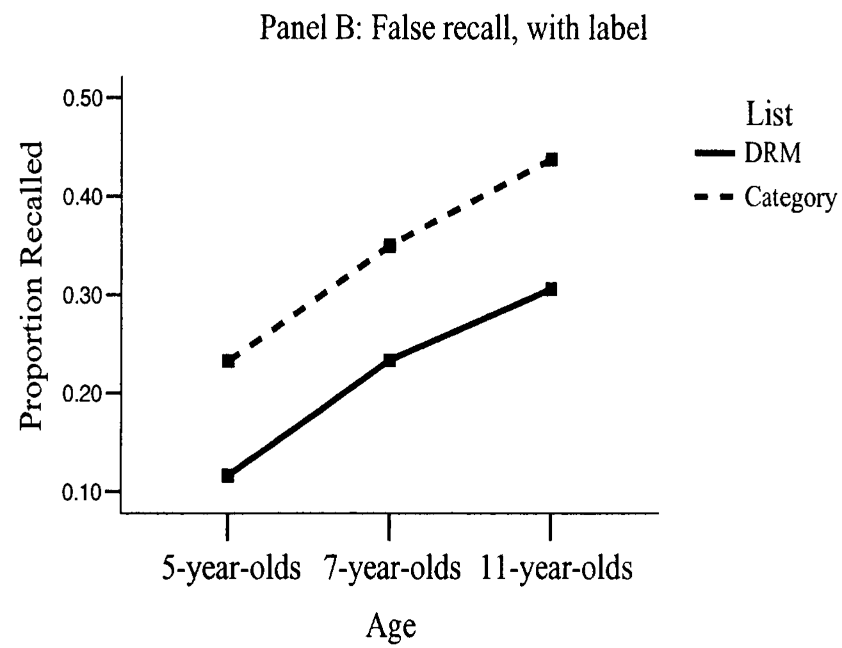


Figure 2. Children's false recall of standard DRM and category word list without (Panel A) and with (Panel B) descriptive labels.





for DRM lists (M = .252) than category lists (M = .356), and label $F(1, 244) = 10.06$, p = .002, partial $\eta^2 = .040$, where more items were recalled when descriptive labels were present (M = .320) than not (M = .288). Main effects of strength $F(2, 243) = 6.75$, p = .001, partial η^2 = .027 and age $F(2, 244) = 199.14$, $p < .001$, partial $\eta^2 = .620$ were also found, where pairwise comparisons ($p < .05$) indicated that High BAS-Low FAS lists yielded significantly more correct recall (M = .313) than High BAS-High FAS (M = .303) and Low BAS-High FAS lists (M = .294). As illustrated in Panels A and B of Figure 1, and confirmed by post-hoc Fisher's LSD analyses ($p < .05$), 5-year-olds (M = .182) recalled less than 7-year-olds (M = .301), who in turn recalled less than 11-year-olds (M = .428). Thus, as compared to DRM lists, category lists resulted in higher rates of correct recall. A similar trend was also found when children were provided with descriptive labels prior to list presentation, where true recall of children in the label condition was greater than that of children in the no label condition.

There were three first-order interactions for true recall. The first was a List x Age interaction, $F(2, 244) = 5.85$, $p = .003$, partial $\eta^2 = .046$. As can be seen in Panel B of Figure 1 and confirmed by post-hoc tests ($p < .05$), although rates of true recall were greater for category than DRM lists across all age groups, the difference between the two lists was smaller for the youngest children than the 7-year-olds and the 11-year-olds. Post-hoc analyses ($p < .05$) of the second interaction, Strength x Age, $F(4, 488) = 6.527$, $p < .001$, partial $\eta^2 = .051$, showed that only older children's true recall was significantly greater for High BAS-Low FAS lists, where 5- and 7-year-olds rates of correct recall were unaffected by varying associative strength across lists. Also, true recall for DRM and category lists was differently effected by associative strength, List x Strength, F(2,

488) = 34.01, $p < .001$, partial $\eta^2 = .122$, where pairwise comparisons ($p < .05$) indicated that rates of true recall were significantly higher for High BAS-High FAS DRM lists ($M = .266$) than High BAS-Low FAS ($M = .238$) and Low BAS-High FAS DRM lists ($M = .251$) and greater for High BAS-Low FAS category lists ($M = .389$) than High BAS-High FAS ($M = .340$) and Low BAS-High FAS ($M = .338$) category lists.

Thus, children of all age groups tended to recall more target items for category lists than DRM lists. On the other hand, only older children's true recall was influenced by variations in lists' associative strength. Descriptive labels also increased children's rates of true recall, and as indicated by the lack of an Age x Label interaction, this effect was seen across age groups. Finally, children's correct recall for category and DRM lists was differently affected by variations in associative strength, where the true recall for category lists was enhanced by High BAS-Low FAS and true recall for DRM lists was enhanced by High BAS-High FAS.

False Recall

Next, recall for critical lures was examined (see Figure 2). In this study, lures for the DRM lists consisted of the target items associated with the list items and lures for the category lists were the unpresented top exemplar for each list (consistent with Howe, 2006; Seamon et al., 2000). False recall was analyzed using a 2(List: DRM vs. category) x 3(Strength: High BAS-High FAS vs. High BAS-Low FAS vs. Low BAS-High FAS) x 3(Age: 5-year-olds vs. 7-year-olds vs. 11-year-olds) x 2(Label: No label vs. label) mixed ANOVA where list and strength were within-subject factors and age and label were between-subjects factors. Again, main effects of list, $F(1, 244) = 30.89$, $p < .001$, partial $\eta^2 = .112$, and label $F(1, 244) = 14.51$, $p < .001$, partial $\eta^2 = .056$ were found, where

DRM lists generated less false recall ($M = .203$) than category lists ($M = .282$) and subjects in the no label condition recalled fewer critical lures ($M = .205$) than those who received a descriptive label prior to list presentation ($M = .279$). Main effects of strength, $F(2, 243) = 70.88, p < .001$, partial $\eta^2 = .368$, and age, $F(2, 244) = 36.58, p < .001$, partial $\eta^2 = .231$ were also found, where post-hoc analyses ($p < .05$) indicated that High BAS-Low FAS lists ($M = .330$) generated higher false recall than High BAS-High FAS lists ($M = .253$), which in turn created more false recall than Low BAS-High FAS lists ($M = .144$). The age pattern was similar to that of true recall where, 5-year-olds ($M = .138$) falsely recalled fewer lures than 7-year-olds ($M = .251$), who in turn falsely recalled fewer lures than 11-year-olds ($M = .339$). Thus, as in true recall, false recall increased with age, was greater for category than DRM lists, was also enhanced when descriptive labels were provided, and was greater for lists where backward associative strength was high and forward associative strength was low.

The analyses also revealed three first-order interactions. As seen in Figure 3, post-hoc analyses ($p < .05$) of the first interaction, List x Label, $F(1, 244) = 8.83, p = .003$, partial $\eta^2 = .035$, showed that false recall for category lists significantly increased when descriptive labels were provided. This effect was not replicated for DRM lists, where the rates of false recall were unaffected by the presence of a descriptive label. Interestingly, when descriptive labels were not provided, children's false recall for category lists was not significantly different than for DRM lists. Analyses of the second interaction ($p < .05$), Strength x Age, $F(4, 488) = 5.09, p = .001$, partial $\eta^2 = .040$, revealed that each age group recalled more critical lures for lists with High BAS-Low FAS, and with the exception of 5-year-olds, more for the High BAS-High FAS lists than the Low BAS-High

Figure 3. False recall for DRM and category lists with and without labels.

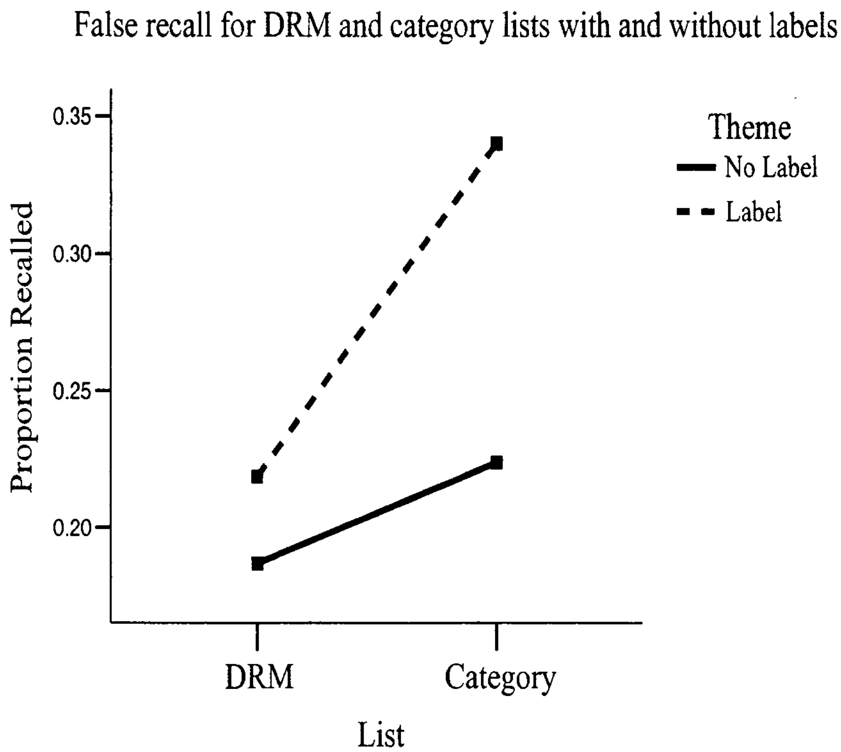
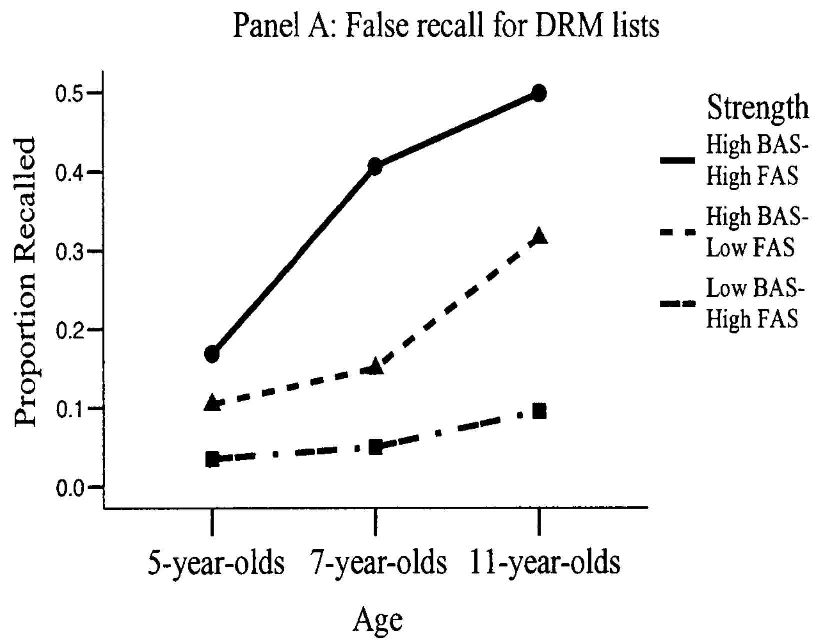
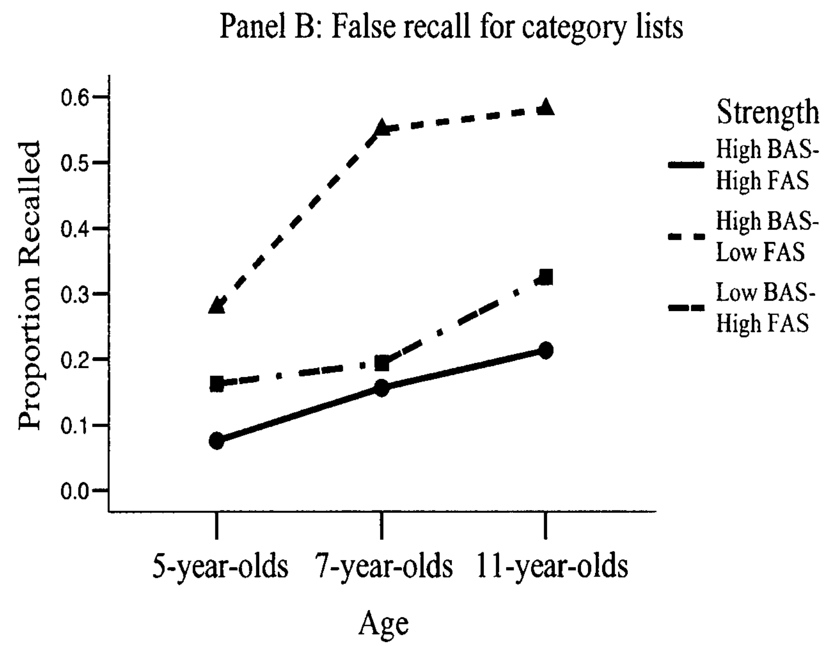


Figure 4. Children false recall of DRM (Panel A) and category (Panel B) lists with variations in associative strength.





FAS lists. However, for the final type of associative strength, Low BAS-High FAS, 11-year-old falsely recalled significantly more critical lures than both 5 and 7-year-olds. Lastly, post-hoc tests ($p < .05$) of the third first-order interaction, List x Strength, $F(2, 488) = 116.17$, $p < .001$, partial $\eta^2 = .323$, showed that false recall rates for category lists were higher than DRM lists for lists with High BAS-Low FAS and Low BAS-High FAS, however they were higher for DRM for High BAS-High FAS lists. There was also a second-order interaction for false recall, List x Strength x Age, $F(4, 488) = 7.58$, $p < .001$, partial $\eta^2 = .058$. Results of this interaction will be discussed as illustrated in Panel A and B of Figure 4. As confirmed by post-hoc tests for DRM lists ($p < .05$), High BAS-High FAS lists produced higher rates of false recall than Low BAS-High FAS lists for all age groups, and High BAS-Low FAS lists generated higher rates of false recall than Low BAS-High FAS lists for 7-year-olds and 11-year-olds. This interaction also revealed that both groups of older children falsely recalled significantly more critical lures than 5-year-olds for High BAS-High FAS lists, that 11-year-olds' false recall was greater than 5-year-olds and 7-year-olds for High BAS-Low FAS lists, and greater than 5-year-olds' for Low BAS-High FAS lists. It appears that strong associative lists in both directions within DRM lists increase false recall rates across age groups.

The next Panel of Figure 4 illustrates the results of this interaction for category lists. In this case, false recall was greater for High BAS-Low FAS lists than Low BAS-High FAS lists for all age groups, which in turn was greater for High BAS-High FAS lists for 5-year-olds and 11-year-olds. Both groups of older children had greater rates of false recall for High BAS-High FAS and High BAS-Low FAS lists than the 5-year olds, and 11-year olds falsely recalled more than both groups of younger children for Low

BAS-High FAS lists. Thus, for category lists, strong associative relations in either direction, more so backward than forward, lead to more false recall.

Summary of Findings

True and false recall of children of all ages was greater for category than DRM lists. Similar findings were also found for descriptive labels. For children of all ages, true recall was enhanced when descriptive labels were provided. However, descriptive labels differentially influenced false recall of category and DRM lists. More specifically, only false recall for category lists significantly increased when descriptive labels were provided prior to list presentation. This increase in false recall was not found for DRM lists, where false recall was unaffected by the provision of descriptive labels. Furthermore, when descriptive labels were not provided, false recall for DRM and category lists did not significantly differ. Differences in rates of true and false recall were also found for variations in list associative strength. Lists with strong backward associative strength and low forward associative strength produced higher rates of correct recall. False recall for both lists was differentially affected by associative strength. For DRM lists false recall was greater for High BAS-High FAS lists than High BAS-Low FAS lists, which in turn produced more false recall than Low BAS-High FAS lists. On the other hand, false recall for category lists was greater for High BAS-Low FAS lists than Low BAS-High FAS which in turn generated more critical lures than High BAS-High FAS lists.

Interestingly, children's rates of false recall for each associative strength for both DRM and category lists also varied with age. For DRM lists where both BAS and FAS was high, the performance of 7-year-olds was not significantly different than that of 11-

year-olds, however, this effect did not remain for lists where BAS remained high and FAS was diminished. In this latter case, 7-year-olds performance was no different than that of 5-year-olds. Similarly, although it remained higher than 5-year olds, 11-year-olds false recall on Low BAS-High FAS lists was no different than 7-year-olds. Thus, according to these results, it appears that, with age, false recall increases for DRM lists as backward associative strength remains relatively high, and will be even more facilitated if accompanied by high forward associative strength.

The scenario differs for category lists, where 7-year-olds' false recall was no different than 11-year-olds' for both High BAS-Low FAS lists and High BAS-High FAS lists. However, for lists where backward associative strength was low and forward associative strength was high, the rates of false recall for 5-year-olds were no different than 7-year-olds. Thus, for category lists, false recall increased with age as backward associative strength remained high, and unlike DRM lists, was lower when accompanied by high forward associative strength, and lowest when backward associative strength was low.

In summary, as in Howe (Experiment 1, 2006), when children were not given descriptive labels prior to list presentation, only rates of true recall for category lists were enhanced, whereas rates of false recall were no different than those for DRM lists. More specifically, within-lists thematic relations influenced rates of true recall only. Therefore, when children are required to spontaneously extract relational information across list items, true recall is greater for lists where categorical relations are present than those where only strong associative relations exist. False recall, on the other hand, is not influenced by the addition of within-list thematic relations.

However, unlike Howe's results (Experiment 2, 2006), both true and false recall increased for category lists when descriptive labels were provided. Although this did not occur for false recall of DRM lists, it appears that children's false memories benefited from the descriptive cue provided prior to the presentation of category lists. This effect is particularly surprising since, as in previous research, list items were blocked during presentation to facilitate spontaneous thematic extraction. A possible explanation for this increase in false recall for category lists may be related to the high levels of association between their critical lures and their respective descriptive labels as compared to those of DRM lists.

Despite the increase in false recall for category lists with the provision of descriptive labels, these results are consistent with previous findings with children (Howe, 2006). The effects of categorical relations were limited to true recall, where rates of true recall were higher for category than DRM lists. False recall, on the other hand, was unaffected by the categorical relations, where rates of false recall did not significantly differ for category and DRM lists when labels were not provided.

Discussion

The purpose of this study was to (a) examine the differential effects of category and associative lists on children's true and false recall, (b) determine the effect of associative strength on children's false memories, (c) examine children's ability to spontaneously extract the overall meaning of word lists, and (d) provide additional information on developmental trends in children's true and false memories. More specifically, the development of associative relations and children's ability to elicit them during list presentation to generate true and false memories was examined using a standardized tool, the DRM paradigm with associative and category lists, both which have previously been used in children and adult false memory studies. Each of these questions and their implications will be examined below.

Differential Effects of Category and DRM lists on True and False Recall

The findings of this study clearly indicated that, as in Howe (2006), category lists facilitate true recall in children across all age groups. Unlike Howe's (2006) previous results, the use of category lists also yielded higher rates of false recall than DRM lists. However, this effect was limited to conditions where a descriptive label was provided prior to list presentation. These results may be related to the inherent differences in the construction of the lists and characteristics of the critical lure for category and DRM lists.

That both true and false recall is higher for category than DRM lists may be related to category lists graded structure (Smith et al., 2000). Category exemplars lie on a continuum of category representativeness, where items in the beginning of the list are prototypical examples associated with a given category and where each consecutive item becomes less representative of its category, sharing fewer features with top exemplars (Barsalou, 1985). Category lists are also not devoid of associative relations. In fact, top exemplars in category norms are highly associated with the category label (Hutchinson, 2003). In this study, critical lures for category lists consisted of the most frequently generated item in response to category labels during free association norms. Providing the descriptive label prior to category list presentation may have directly primed the critical lure, which in turn was additively primed through the presentation of consecutive list items. Thus, providing descriptive labels highly associated with a critical lure likely ensured, given available category knowledge, that the critical lure, along with list items, be activated prior to list presentation.

Although these findings can be interpreted as being consisted with FTT, where descriptive labels increased young children's processing of across-item relations leading to increased false recall, the role of associative relations should not be minimized. Providing descriptive labels prior to category list presentation may have primed all prototypical exemplars, especially the one most highly associated with the category label, which in this case, is the critical lure. In fact, this assumption is supported by previous research on category cued recall where false recall (for all related critical intrusions) was correlated ($r = .72$) with output dominance, where output dominance relates to the frequency to which an item is elicited in the production of category norms (Smith et al., 2000). Similarly, superordinate cues, such as the category labels, have been found to efficiently aid recall in both children and adults (Blewitt & Toppino, 1991). In the context of this study, providing a superordinate cue prior to list presentation may have activated children's prototypical exemplars (the critical lure) for a given category. During subsequent list presentation, the critical lure may have been additionally primed through its associative relations with other top exemplars, leading to an increased probability of false recalling it along with other list items.

Due to selection criteria based on mean backward and forward associative strength, the category lists selected for this study were considerably lower in associative strength as compared to that of DRM lists. As established through personal communication, the total associative strength for category and DRM lists used in Howe (2006) did not significantly differ (M. L. Howe, personal communication, June, 2006). The provision of a descriptive label highly associated with prototypical exemplars for a given category was likely favourable in priming associative relations within a category in this study, especially given that mean backward and forward associative relations between list items and the lure were relatively low. However, that rates of both true and false recall for category lists benefited from the provision of a descriptive label when associative links were weak does not imply that delineating the semantic relations within lists increases gist processing. In fact, when results for category and DRM lists are taken together, the assumptions of associative theories can not be underestimated.

As previously mentioned, recent findings with children (Howe, 2006) and adults (Hutchinson & Balota, 2005) have indicated that true and false recall are influenced by different factors, where true recall is influenced by semantic relations and false recall by associative relations. The results from this study clearly indicate that true recall for both DRM and category lists benefited from the semantic information provided by descriptive labels, however only category lists' false recall increased in conditions where descriptive labels were provided prior to list presentation. Again, this effect was most likely related to the strong associative relations between the critical lure and descriptive labels for category lists. In fact, further investigations revealed stronger associative relations between the critical lures (top exemplars from category norms) and the descriptive labels for category lists (M = .34) than for DRM (M = .13), further supporting the role of associative relations in the increased proportions of false recall for category lists when descriptive labels were provided. Thus, as in previous research with adults and as proposed by associative theories, children's veridical recall was driven by lists' semantic relations, whereas their false recall was driven by associative relations between concepts.

Another important finding that is particularly difficult to account for by theories relying on the development of gist processing abilities is the lack of an Age x Label interaction for both true and false recall. To account for the developmental trend, fuzzy-trace theory proposes that false memories will increase with age as children's abilities to process across-list semantic relations become better developed. According to these assumptions, it would be expected that 5-year-olds' false recall, unlike 11-year-olds', benefit from the provision of label describing the semantic relations shared across list items. However, the results from this study did not indicate such a trend. Instead, the results support the assumptions of associative theories as well as recent findings on the dissociation of true and false memories. When provided with descriptive labels poorly associated with list items and the critical lure, as those for DRM lists, only rates of true recall increased for children across all age groups. On the other hand, their false recall did not differ from that of children where descriptive labels were not provided. Thus, when devoid of strong associative links to the critical lure, descriptive labels provide thematic information only useful to children's correct recall. The respective roles of thematic and associative information on true and false recall were further outlined with the use of category labels. Due to their strong associative relations to the list items and the critical lure, the presentation of category descriptive labels prior to list presentation enhanced both thematic and associative relations. As predicted by associative theories and previous results on the dissociation of true and false recall, this resulted in increased rates of children's true and false recall for category lists as compared to those of DRM lists.

The lower proportions of true and false recall for DRM lists may also be associated to within-subject task demands, where the use of two different types of lists within a same task may have encouraged the use of different memory strategies in children. As stated by Bjorklund and de Marchena (1984), although associative processing is actively used at a young age, even young children will use categorical relations in addition to associative relations if this results in more efficient processing. Given that conditions were made favourable for children provided with descriptive labels, the processing of both semantic and associative relations for category lists was facilitated, which in turn resulted in increased proportions of true and false recall, respectively. As later discussed, the development of automaticity in associative priming is a major factor contributing to the increase in children's false recall.

Associative Strength and False Recall

Similar to previous findings with associative lists in the adult literature (Roediger et al., 2001; McEvoy et al. 1999), where backward associative strength is the main contributing factor to the production of false memories, the results indicate that lists with high backward associative strength and low forward associative strength yielded the highest rates of false recall across all age groups. However, false recall for category and DRM lists proved to be sensitive to different types of associative strength. More specifically, for DRM lists, false recall was highest for lists with high backward and forward associative strength, whereas category lists yielded the most false recall when backward associative strength was high and forward associative strength was low. These results will be discussed in light of previous findings with adults; however, it is to be noted that to date, this is the first and only research to examine the effects of associative relations in children's DRM false memory development.

As in Brainerd and Wright (2005), who used false recognition measures with adults, children's false recall was similarly effected by variations in associative strength for DRM lists, where false recall was greater for DRM lists with high backward associative strength and high forward associative strength, followed by lists with high backward associative strength and low forward associative strength, and low backward associative strength and high forward associative strength, respectively. Past studies with adults examining the effects of associative strength on false recall have mostly focused on the role of backward associative strength, where lists with high and low backward associative strength were included regardless of forward associative strength. Thus, to date, no previous study on children's false recall has examined the role of forward associative strength by directly manipulating it along with backward associative strength.

The effects of forward associative strength appear to depend on the initial ability of list items to prime the critical lure. Once primed by the list items, the lure's associative links to the list items also become activated. This appears to be limited to instances where both backward associative strength and forward associative strength are substantial. More specifically, high forward associative strength must be accompanied by high backward associative strength to increase false recall, where false recall was lowest for lists where only forward associative strength was strong. Interestingly, this effect was not influenced by across-item gist. In fact, descriptive labels highlighting shared features among list items failed to increase rates of false memories for DRM lists. Therefore, as in adults, children's false recall for DRM lists was enhanced when strong bi-directional associative relations exist between list items and critical lures and this was unaffected by across-list semantic information. Taken together, these results indicate that for DRM lists, the activation of strong associative links between concepts and lures results in increased false recall.

To date, no study has examined the role of associative strength in children's false recall for category lists. The results of this study indicate that children's false recall of critical lures for category lists was enhanced by strong associative relations in either direction (more so for backward than forward), but, unlike DRM lists, not in instances where both types of associative strengths were substantial. This particular finding is somewhat puzzling in that although lists with strong backward associative strength yielded the highest proportion of critical lures when accompanied by poor forward associative strength, lists where both backward associative strength and forward associative strength were strong resulted in the lowest proportion of false recall. A possible explanation is that, the backward associative links for category lists with high backward and low forward associative strength were particularly well established for the children in this study. Taking a closer look at the list themes (transportation vehicles and fruits) does support this assumption since these topics are encountered early and frequently in children's life. Associative priming may have been facilitated for these lists since the links between conceptual representations were well defined for children of all ages. In fact, false recall rates were higher for these lists than any other list included in this study.

Differential Effects of Descriptive Labels for Category and DRM Lists

In this study, children's ability to spontaneously extract relational themes from DRM and category lists was examined. The provision of descriptive labels was also used to examine the role of semantic information on children's false memories for both categorical, as in Howe (2006), and DRM lists. Contrary to the proposed hypothesis, children's true recall for both types of lists was significantly greater when descriptive labels were provided prior to list presentation. However, as previously mentioned, only category lists' false recall was affected by descriptive labels. This later effect may be related to the strong associative relation between the critical lure and the descriptive label rather than children's inability to extract thematic information from category lists.

Although the descriptive labels for DRM were not standardized as were those for category lists, they served the same purpose, that is, to highlight the shared features among list items. Fuzzy-trace theory proposes that it is children's poor abilities at extracting gist relations across list items that result in lower false memory rates. Yet, in this study, even when provided with an overall description of the shared aspects of the DRM list items children's rates of false memories did not differ from those of children who did not receive this information. This finding could indicate two things: that children are capable of extracting the overall meaning of lists' items, and/or that this type of information is not of use in the production of children's false memories for DRM lists.

Current findings with adults (Hutchinson & Balota, 2005) and children (Howe, 2006) found that false recall was unaffected by the presence of information delineating lists' shared semantic meaning. Instead, associative relations between list items and the critical lure played a major role in eliciting the critical lure along with other list items during free recall. Whether children in this study were capable of spontaneously extracting the gist remains unknown, however, when the overall gist of DRM lists was provided to children, this information did not significantly increase their false recall. On the other hand, increases in associative strength, although specific types for both lists, did significantly increase children's false recall. This finding is consistent with theories proposing that related, yet unpresented concepts are also included in episodic memory due to their activation through associative links with presented items (see Hutchinson & Balota, 2005).

Developmental Trends in True and False Memories

The results of this study are consistent with those of previous research with children (Brainerd et al., 2002, Howe et al., 2004), where both true and false recall increased across all age groups. However, false memories did not increase for all variations in associative strength nor did it increase across all age groups. Furthermore, differences across age groups for associative strength also varied for category and DRM lists.

Category lists with high backward associative strength accompanied by low forward associative strength produced the highest rates of false recall across all age groups. This type of associative relations between concepts sharing the same thematic meaning appears to be processed early in young children, where 7-year-olds performance was similar to that of 11-year-olds. A similar trend was also found for lists with high backward associative strength and forward associative strength; however, these lists yielded the lowest proportion of false recall. Lists where forward associative strength was strong and backward associative strength was low yielded a different age trend where the performance of 5-year-olds was similar to that of 7-year-olds. It appears that, for thematically consistent materials, backward associative links are the first to become more easily activated and are most important in the production of false memories. Forward associative links on the other hand are more difficult to prime and perhaps slower to develop possibly requiring more elaboration and definition of the category boundaries, which will be gained through increasing knowledge and experience.

As previously mentioned, increases in false recall for category lists may be attributable to the strong associative relations between the top list exemplars and the critical lure and the prototypical nature of these exemplars (including the critical lure) for their given category. More specifically, high proportions of true and false recall may indicate that for specific category lists, in this case, lists with high backward and low forward associative strength, children were especially knowledgeable. As stated by Bjorklund (1987), associative links between concepts become stronger with increases in knowledge and experience. Given that the category lists with high backward and low forward associative strength included in this study are encountered frequently starting at a very young age (*Fruit* and *Transportation vehicles*), children's knowledge and consequently associative links between category members may be well established.

Although children's overall trend of false memories for DRM lists with varying backward and forward associative strength was similar to those of adults, this did not hold across all age groups. As in adults, lists where both backward and forward associative strength were strong produced the highest proportions of false recall across all age groups, where 7-year-olds false recall was similar to that of 11-year-olds. As previously mentioned, high forward associative strength, when combined with backward associative strength, may facilitate priming of the associative links between items and the critical lure for DRM lists. This is apparent in that the performance of 5- and 7-year-olds was similar for lists with high backward and low forward associative strength but where

7-year-olds performance became similar to that of 11-year-olds for lists when both backward and forward associative were strong. Young children, on the other hand did not benefit from this addition in forward associative strength. Forward associative links were the most difficult to activate, where lists with poor backward and strong forward associative strength yielded the lowest proportion of false recall. In this case, 11-year-olds performance was only significantly greater than 5-year-olds. Thus, it appears that young children's ability to prime backward associative relations exceeds those for forward associative relations starting at a very young age. However, by the age of 7, children are able to process additional forward associative links along with backward associative links.

Current findings on children's false recall have revealed that children's ability to process associative relations require more cognitive effort than for adults. Although associative relations between concepts are present by early childhood, their quality and strength continue to develop as children gain more knowledge and experience (Bjorklund, 1987). Similarly, children's cognitive abilities will also increase as they get older, which will allow them to process information more efficiently. Recent results on children's false memories have proposed that young children's lower proportions of false recall are related to their inability to spontaneously prime the associative relations between items and the critical lure (Howe, 2006; Howe, 2005). However, as children get older, the activation of associative links between concepts becomes more automatic requiring less conscious effort. Thus, children's proportions of false recall will continue to increase as children's processing of associative relations becomes progressively more automatic and as knowledge and experience gains strengthen associations between concepts.

Related theories based on global memory development (such as trace-integrity theory – see Howe, 2000) propose that memory development is simply a change in the dynamics of memory, where with age, information is processed more efficiently due to increased representational strength of concepts and their associative relations. In terms of false memories, age increases in associative strength and automaticity lead to greater spontaneous priming of the critical lure through its associative links with list items. Consecutively, as predicted by associative theories, this associative activation of the critical lure through list items results in the erroneous inclusion of the unpresented but related lure during recall.

Previous findings examining the role of backward associative strength within the DRM paradigm have proposed that the critical lure is included during recall because of its summative associative activation through its backward associative links with list items (Roediger et al., 2001). Similarly, earlier research with adults proposed that a list's total, rather than its mean backward associative strength, is a better predictor for false recall (Robinson and Roediger, 1997). The results from this study partly corroborate these findings. Although mean associative strength for DRM lists is higher than for category lists, the associative strength, both forward and backward, of the first few exemplars to the critical lure are typically in the same range as those for DRM. Furthermore, when descriptive labels were not provided, false recall for category lists was similar to that of DRM lists. Thus, activation of the lure from the items with the strongest associative links may be sufficient in ensuring that it be elicited along with list items at recall.

Children's processing for both list types may have differed during this study, where adaptive measures may have been taken where active treatment of useful information, such as thematic information for category lists, resulted in more efficient processing of list items. Similarly, between-list differences may have also effected children's cognitive processing, where category lists, perhaps due to their graded effect, were perceived as more thematically consistent than DRM lists. This is feasible in that the category lists from this study are frequently encountered by young preschool children. Thus, the associative links between concepts of familiar categories, as those included in this study, may already be stronger than some for DRM lists.

Limitations

Three major limitations of this study are related to the imposed restriction in list selection as required by the design of this study, and to the abilities of the target population considering the nature of the task.

First, differences in results with Howe (2006) may be related to the associative strength requirements of this study. As previously mentioned, mean associative strength for category lists was much lower than those of DRM lists in the same associative strength group. As established through personal communication, this limitation was not an issue for Howe (2006), as total associative strength for both list types did not significantly differ (M. L. Howe, personal communication, June 2006). Thus, for Howe (2006), providing a descriptive label probably did not further activate associative relations between category list items and the lures as these were most likely sufficiently primed through list presentation. However, due to lower mean associative strength between the critical lures and list items for category lists, providing descriptive labels in this study possibly enhanced the activation of weakly primed associative links during encoding. As previously mentioned, this priming was favorable in that labels for category lists were strongly associated to their respective critical lures.

Second, the DRM lists included in this study may have not been ideal for young children. Although it is expected that even young children could understand the list items, whether they could independently deduce the shared associative relations between list items is questionable for some lists. However, the results did not indicate that younger children benefited more than older children from descriptive cues. As reported by the results of this study, even when provided with poorly associated descriptive labels highlighting the shared features across list items, false recall for DRM lists did not increase. This effect was also seen across all age groups.

Finally, the demands and length of the task may have also diminished the overall rates of recall. All children who participated in this study were required to encode and recall 14-items from a total of 12 lists. This may have been particularly difficult for some, especially children as young as 5 years-old, given that close attention was required to effectively encode and activate list items and their associative relations. Evidently, it is unlikely that lapses in attention did not occur during list presentation for children of all ages. Unfortunately, a related cost of this is perhaps decreased activation of associative links for list items due to an initial failure to prime all associative relations during list presentation, which in turn would result in lower false memory rates.

Given these limitations, these results are nonetheless consistent with the assumptions of associative theories. False recall for children of all ages benefited from associative activation of the critical lure provided by strongly associated descriptive labels. As in past research with children and adults (Howe, 2006; Hutchinson & Balota, 2005), when thematic information was provided without the presence of strong associative relations, only rates of true recall increased for children. These results are also consistent with theories on the development of memory, where increases in automaticity and changes in memory storage both influence the associative activation and reporting of the critical lure. Thus, it appears that, unlike the assumptions of gist-based theories, across-list semantic priming does not influence children's production of false memories, but rather is limited to influencing rates of veridical recall.

Conclusion

This study has indicated that as in adults, children's false memories are also influenced by strong associative relations between list items and critical lures. The strong influence of associative priming on false recall is particularly difficult to account for by gist-based theories such as fuzzy-trace theory. Furthermore, the results did not support the assumption of fuzzy trace theory, proposing that children's false memories are related to their poor ability to extract semantic relations across list items. As in adult's, dissociations between true and false memories also existed, where the effects of strong semantic relations are limited to true recall and those of strong associative relations to false recall. These findings suggest that children's false memories can be interpreted within the same theoretical framework as adults, where increased susceptibility to the false memory illusion is related to the strengthening of associative links between associated concepts and the development of automaticity in processing these associative relations.

Further Implications

Given that throughout development increasing experience and knowledge result in stronger associative relations, children's rates of false memories, as proposed by associative theories, also increase with age. However, in specific instances, it is possible that younger children's associative relations between related concepts be stronger than those of older children and adults. For example, children's expertise in certain domains of interest (e.g. prehistoric animals) may result in stronger associative relations between concepts as compared to adults. Thus, in accordance with the assumptions of associative theories, this would result in the reversal of the false memory developmental trend, where children would be more prone than adults to activate associated unpresented items.

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Appendix

Associative Strength of DRM and Category Lists

DRM Word Lists and Labels

High BAS – Low FAS
Critical Lure: Smell
Label: Something to do with your senses
MBAS: 0.290 MFAS: 0.015

ITEM	BAS	FAS
Nose	.108	.116
Breathe	0	0
Sniff	.442	.043
Aroma	.678	0
Hear	0	0
See	0	0
Nostril	0	0
Whiff	.577	0
Scent	.625	.029
Reek	.510	0
Stench	.562	0
Fragrance	.389	0
Perfume	.393	.036
Salts	.028	0

Critical Lure: Mountain
Label: Things to do with high places
MBAS: 0.154 MFAS: 0.037

ITEM	BAS	FAS
Hill	.428	.265
Valley	.195	.020
Climb	.291	.092
Summit	.108	0
Top	0	.041
Molehill	.256	.031
Peak	.248	.020
Plain	0	0
Glacier	.020	0
Goat	.028	0
Bike	.033	0
Climber	.603	.031
Range	0	.051
Steep	.061	0

High BAS – High FAS

Critical Lure: Needle
Label: Something to do with spiky objects
MBAS: 0.203 MFAS: 0.063

ITEM	BAS	FAS
Thread	.76	.42
Pin	.29	.21
Eye	0	0
Sewing	.181	.24
Sharp	.03	.02
Point	.02	.02
Prick	.11	.01
Thimble	.22	0
Haystack	.42	.03
Thorn	.03	0
Hurt	0	0
Injection	.33	0
Syringe	.52	0
Cloth	0	0

Critical Lure: Doctor
Label: Medical things
MBAS: 0.245 MFAS: 0.053

ITEM	BAS	FAS
Nurse	.55	.38
Sick	.03	.05
Lawyer	.15	.10
Medicine	.15	.07
Health	.05	.02
Hospital	.03	.01
Dentist	.21	.02
Physician	.80	.04
Ill	0	.01
Patient	.37	.03
Office	.01	.01
Stethoscope	.520	0
Surgeon	.48	.04
Clinic	.30	0

Low BAS – High FAS

Critical Lure: Lamp
Label: Things that help you see
MBAS: 0.006 MFAS: 0.066

ITEM	**BAS**	**FAS**
Light	.020	.769
Shade	.028	.058
Bulb	.014	.045
Post	0	.026
Black	0	0
Cord	0	0
Desk	.034	.019
Bright	0	0
Lighter	0	0
Read	0	0
On	0	0
Burn	0	.013
Pole	0	0
Stand	0	0

Critical Lure: Cabbage
Label: Something that you eat
MBAS: 0.11 MFAS: .051

ITEM	**BAS**	**FAS**
Head	.000	.022
Lettuce	.021	.281
Vegetable	.000	.137
Food	.000	.022
Salad	.000	.022
Green	.000	.079
Garden	.000	.000
Leaf	.000	.029
Sauerkraut	.042	.000
Slaw	.041	.043
Patch	.066	.115
Plant	.000	.000
Carrots	.000	.000
Soup	.000	.014

Category Word Lists and Labels

High BAS – Low FAS

Critical Lure: Apple
Label: Fruit
MBAS .049 MFAS .018

ITEM	BAS	FAS
ORANGE	.08	.17
BANANA	.15	.02
GRAPE	.03	0
PEAR	.25	.05
PEACH	.06	.03
STRAWBERRY	0	0
KIWI	0	0
PINEAPPLE	0	0
WATERMELON	0	0
TOMATO	*.01*	0
PLUM	.05	0
GRAPEFRUIT	*.01*	0
MANGO	0	0
CHERRY	.08	0

Critical Lure: CAR
Label: Transportation vehicle
MBAS: 0.13 MFAS: 0.02

ITEM	BAS	FAS
BUS	.25	.02
TRUCK	.26	.11
AIRPLANE	.03	.01
TRAIN	.06	.01
BICYCLE	.04	.08
VAN	.45	0
BOAT	0	.06
MOTORCYCLE	.09	0
SKATEBOARD	0	0
SUBWAY	.03	0
TAXI	.13	0
SCOOTER	0	0
JEEP	*.30*	*.01*
HELICOPTER	0	0

High BAS – High FAS

Critical Lure: Instrument
Label: Musical things
MBAS: 0.125 MFAS: 0.039

ITEM	**BAS**	**FAS**
DRUMS	.01	.05
GUITAR	.05	.15
FLUTE	.18	.08
PIANO	.04	.16
TRUMPET	.18	.07
CLARINET	.12	.03
SAXOPHONE	.24	.02
VIOLIN	.06	.02
TROMBONE	.17	0
TUBA	.25	.01
CELLO	.15	0
OBOE	.18	0
BASS	.03	0
HARP	.08	0

Critical Lure: Chair
Label: Pieces of Furniture
MBAS: 0.156 MFAS: 0.037

ITEM	**BAS**	**FAS**
TABLE	.76	.31
COUCH	.29	.11
BED	0	.01
DESK	.29	.02
SOFA	.13	.08
DRESSER	0	0
LOVESEAT	0	0
NIGHTSTAND	NA	0
OTTOMAN	0	0
RECLINER	.55	0
STOOL	.32	.03
FUTON	0	0
BOOKSHELF	0	0
CABINET	.02	0

Low BAS – High FAS

Critical Lure: Hammer
Label: Carpenter's tools
MBAS: 0.089 MFAS: 0.056

ITEM	BAS	FAS
NAIL	.62	.80
SAW	.10	.03
SCREWDRIVER	.08	0
DRILL	0	0
WRENCH	.09	0
SCREW(S)	.03	0
LEVEL	0	0
RULER	0	0
TAPE MEASURE	0	0
WOOD	0	0
SANDER	0	0
KNIFE	0	0
CHISEL	*.41*	*.05*
PENCIL	0	0

Critical Lure: Fly
Label: Insect
MBAS: 0.047 MFAS: 0.021

ITEM	BAS	FAS
ANT	0	0
SPIDER	*.19*	*.02*
BEE	*.01*	*.01*
MOSQUITO	.05	.04
BEETLE	0	0
LADYBUG	0	0
GRASSHOPPER	*.01*	*0*
BUTTERFLY	*0*	*.01*
WASP	.02	0
ROACH	0	.01
MOTH	.11	0
GNAT	*.23*	*0*
COCKROACH	0	0
CATERPILLAR	*.03*	*0*