Published in final edited form as:

Am J Psychol. 2015 ; 128(1): 43–59.

The Controlled Retrieval of Specific Context Information in Children and Adults

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Abstract

The present study adapted a procedure used recently by Luo and Craik (2009) in order to examine whether developmental differences exist in the ability to use controlled retrieval processes to access the specific contextual details of memory representations. Participants from three age groups (Mean ages: 9, 12, and 25 years) were presented with words in three study contexts: with a black-and-white picture, with a color picture, or alone without a picture. Six recognition tests were then presented that varied in the demands (high or low) placed on the retrieval of specific contextual information. Each test consisted of a mixture of words that were old targets from one study context, distractors (i.e., previously studied words from a different context), and completely new words. A “high specificity” and a “low specificity” test list was paired with each test question, with “high” and “low” specificity being determined by the nature of the distractors used in a test list. High specificity tests contained words that were studied in similar contexts: old targets (e.g., words studied with black-and-white pictures) and distractors (e.g., words studied with color pictures). In contrast, low specificity tests contained words that were studied in dissimilar contexts: old targets (e.g., words studied with black-and-white pictures) and distractors (e.g., words previously studied without a picture). Relative to low specificity tests, the retrieval conditions of high specificity tests were assumed to place greater demands on the controlled access of specific contextual information. Analysis of recollection scores revealed that age differences were present on high, but not low specificity tests, with the performance of 9-year olds being disproportionately affected by the retrieval demands of high specificity tests.

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Portions of this research were presented at the annual meeting of the Psychonomic Society in Seattle, WA, November, 2011, and the annual meeting of the American Speech, Language, and Hearing Association in San Diego, CA, November, 2011.

Keywords

developmental differences; recollection; controlled retrieval; context

A number of theorists (e.g., Baltes, Lindenberger, & Staudinger, 2006; Craik & Bialystock, 2006; Dempster, 1992; Kail & Salthouse, 1994; Li & Baltes, 2006; Shing, Werkle-Bergner, Brehmer, Müller, Li, & Lindenberger, 2010) have attempted to capture the nature of lifespan changes in various cognitive processes. One such effort is exemplified in the work of Craik and Bialystock (2006) who presented a framework that focuses on age-related changes in representational processes, control processes, and their interaction. Craik and Bialystock's (2006) representation and control framework builds on Craik's (2002) hierarchical model of memory representation where knowledge and memory are represented on a continuum of specificity ranging from individual, context-specific memories to more general context-free knowledge (see also Conway & Pleydell-Pearce, 2000, who similarly used levels of specificity to describe different types of autobiographical memory). Features shared by related memory episodes comprise higher-level nodes, while events from individual memory episodes form lower-level nodes. For example, I may remember "the early spring day on my 12th birthday when my best friend, Jimmy, and I flew a kite 1400 feet at Mark Twain schoolyard." Recollection of such vivid contextual detail is presumably based on lower-level nodes. In contrast, a more general memory of "flying kites as a child" would represent a higher-level node, and context-free knowledge associated with "flying kites" would reflect yet a higher node. Importantly, "rather than view these types of memory as arising from different systems, the ... suggestion is that they exist on a continuum of specificity running from the individual instances, rich in specific contextual detail, to abstract context-free knowledge, which of course originated from the amalgamation of specific instances" (Craik, 2002, p. 272). Thus, Craik's hierarchical model places different forms of memory along a continuum of specificity, ranging from context-free knowledge (e.g., semantic memory) to memories of contextual details (e.g., episodic memory), with different levels of specificity within these types of memories (Luo & Craik, 2009). Access to lower-level, context-specific representations requires controlled retrieval and the deployment of additional cognitive resources. In contrast, access to higher-level, context-free representations is less controlled and places fewer demands on the use of existing cognitive resources. Given that access to specific episodic details places demands on processing resources, and based on the observation that the aging process is accompanied by a decline in processing resources, Craik (2002) argued that older adults may be expected to experience particular difficulty on tasks requiring memory for specific, as opposed to more general, forms of information.

The framework of Craik and Bialystock (2006) expands the model of Craik (2002) by suggesting that representational processes, control processes, and their interaction evolve over the lifespan. As with the model of Craik (2002), the framework of Craik and Bialystock (2006) is based on the premise that representational systems are organized in a hierarchical manner. Lifespan changes in representation are characterized in terms of their "growth and stability" (Craik & Bialystock, 2006, p. 136): Abstract representational systems are acquired as children develop and are maintained well in older adults. On the other hand, the lifespan changes in the control processes that act on those representations are characterized by their

“growth and decline” (Craig & Bialystock, 2006, p. 136). Such a rise and fall in controlled processing is mediated by the frontal lobes, which are the last areas of the brain to mature and the first to decline in older adults (Craig & Bialystock, 2006). Controlled processing is responsible for the conscious control of one’s thoughts and actions, and is evident in a wide range of abilities including, the controlled process of recollection where the details of a prior memory episode are deliberately brought back to mind.

The present study tests the hypothesis that children improve in their ability to use controlled retrieval processes to access specific contextual details of recent events in episodic memory. Based on the observation that access to lower-level, context-specific representations requires controlled retrieval and additional cognitive resources (Craig, 2002), and to the extent that control systems operating on representational systems improve during childhood (Craig & Bialystock, 2006), it follows that as children grow older they should improve in their ability to use controlled retrieval to access specific details of memory episodes. The following review focuses on areas of research that are relevant to our hypothesis and experimental method, and provide support for the notion that children experience particular difficulty in the controlled retrieval of more detailed episodic information.

Recollection-Based Retrieval Processes in Children’s Recognition Memory Performance

According to dual-process theories (e.g., Jacoby, 1991; Mandler, 1980; Yonelinas, 2002), recognition memory consists of two distinct retrieval processes: familiarity and recollection. Familiarity is considered to be a relatively fast and automatic process where recognition decisions are based on the global strength of a given memory representation. On the other hand, recollection is regarded as a relatively slow process that involves the deliberate retrieval of the qualitative details of prior experiences. Depending on the nature of the recognition task, successful performance may be based merely on familiarity. At other times, however, successful memory depends on the recollection of contextual detail. Recognition tasks may vary in the amount of contextual detail that must be retrieved in order for recollection to be successful. The more a recognition task requires the retrieval of detailed, specific memories, the more the task places demands on controlled access to those representations.

Although relatively few in number, the available studies have used a variety of research paradigms to examine the dual processes of recollection and familiarity in the recognition memory performance of children including, Remember/Know (Billingsley, Smith, & McAndrews, 2002; Friedman, de Chastelaine, Nessler, & Malcolm, 2010; Ofen, Kao, Sokol-Hessner, Kim, Whitfield-Gabrieli, & Gabrieli, 2007; Rhodes, Murphy, & Hancock, 2011), conjoint recognition (Brainerd, Holliday, & Reyna, 2004); Receiver Operating Characteristic fitting approach (Ghetti & Angelini, 2008), picture superiority effect (Defeyter, Russo, & McPartlin, 2009), and process dissociation (Anooshian, 1999; Holliday, 2003; Holliday & Hayes, 2000, 2001). The behavioral and neuro-cognitive evidence generated by these studies indicates that throughout middle childhood and adolescence recollection-based retrieval processes are slower to emerge and manifest greater developmental differences than

familiarity-based retrieval processes. Unfortunately, the existing studies of familiarity- and recollection-based retrieval processes in children do not definitively assess the position that developmental differences in recollection are a function of whether a given task places demands on the ability to access highly specific information. Although recollection was distinguished from familiarity in these studies, levels of specificity of recollection were not varied in the task conditions of individual studies. Consequently, the designs of these studies were not able to directly assess the notion that levels of retrieval specificity exist within tests of recollection, or that developmental differences in recollection increase when demands are placed on retrieval specificity. A more direct test of this interpretation would be obtained if one manipulated the retrieval demands of recognition tasks within a given experiment. If there are age-related improvements in the ability to access highly specific information, age-related changes should be manifested in a condition in which there are increased cognitive demands on the ability to access highly specific information. In contrast, such developmental differences may be eliminated or reduced in a condition that places fewer demands on the retrieval of specific information. The combined pattern of these results would provide support for the observation that developmental improvements in recollection are a function of whether tasks place demands on the ability to access highly specific information.

Another area of research that provides information about age-related improvements in controlled retrieval is source monitoring. “*Source monitoring* refers to the set of processes involved in making attributions about the origin of memories, knowledge, and beliefs ...” (Johnson, Hashtroudi, & Lindsay, 1993, p. 3). Although performances on source monitoring and recognition tasks are frequently discussed separately, each may involve the use of similar processes (Johnson et al., 1993; Mitchell & Johnson, 2009). Often, memory for source information is indirectly involved in tasks measuring event memory. According to the source monitoring framework (Johnson et al., 1993; Johnson & Raye, 1981; Mitchell & Johnson, 2009), when event memories are later brought back to mind they may include a variety of features such as, perceptual information (e.g., color), spatial location (e.g., location), temporal information (e.g., time of day), and so on. The retrieval of such details allows us to specify the source of our memories and to differentiate one event from another. Source attributions may be based on differentiated (i.e., specific attributes of memory, such as color) or undifferentiated information (i.e., nonspecific, such as a sense of familiarity), and may involve two types of judgment processes: One type of judgment is made heuristically (i.e., rapidly, non-deliberately, automatically), while the second type of judgment is performed systematically (i.e., slowly, deliberately, controlled). The retrieval of specific perceptual details requires more systematic processing, whereas decisions based on undifferentiated information involve heuristic processes (Mitchell & Johnson, 2009). Needless to say, the distinction between heuristic and systematic judgment processes parallels the distinction between familiarity- and recollection-based retrieval processes in dual process models of recognition memory.

Theorists in cognitive neuroscience have observed that regions of the prefrontal cortex (PFC) and their interactions with the medial temporal lobes (MTL) play a critical role in controlled retrieval (see review by Simons and Spiers, 2003) and the systematic processing of detailed source information (DeMaster & Ghetti, 2013; Mitchell & Johnson, 2009; Ofen,

2012; Paz-Alonso, Gheiti, Donohue, Goodman, & Bunge, 2008; Shing et al., 2010). Mecklinger, Sprondel, and Kipp (in press) recently reviewed studies that have used the event-related-potential (ERP) technique to examine the developmental trajectories of familiarity and recollection processes in recognition memory, as well controlled retrieval in source memory tasks. Mecklinger and his colleagues concluded that while familiarity, recollection, and their ERP correlates appear to mature early (6 – 8 years), strategic memory retrieval is “limited and inflexible” in younger children. Difficulty remembering contextual details may be attributed to immature systems in the PFC that control retrieval. Mitchell, Johnson, Raye, and Greene (2004; see also Dobbins, Simons, & Schacter, 2004) have proposed that the left and right hemispheres of the PFC provide differential support to heuristic and systematic processing, with the left PFC involved in memory decisions that are based on specific contextual information, and the right PFC involved when decisions are based on undifferentiated information. PFC structures are considered to support control processes that guide the search for contextual detail and monitor/evaluate the results of retrieval efforts (Dobbins et al., 2004). Based on the fact that the PFC has a protracted development and matures well into adolescence (Casey, Giedd, & Thomas, 2000), and given that PFC structures support controlled processing of detailed source information, it is not unreasonable to expect that at least some forms of source monitoring may continue to develop in older children and adolescence. Assuming that the retrieval of highly specific contextual detail requires greater cognitive control than the retrieval of less detailed information (see discussion by Mecklinger et al., in press), it follows that age-related improvements in source memory may depend on whether tasks place demands on the ability to access the contextual details of previously studied information.

Studies that have examined source memory in children have provided evidence consistent with the observation that memory for contextual detail differentiates the performance of younger and older children. Of particular relevance for the present investigation are those studies that have measured the source monitoring of events containing similar sources. As similarity of source information increases, there are additional demands on control processes that select and evaluate the detailed information of memory representations (Sprondel, Kipp, & Mecklinger, 2011). Discriminating between memories of similar sources seems to be particularly difficult for younger children (see discussions by Lindsay, 2008; Roberts, 2002; Roberts & Blades, 2000). Younger children have greater difficulty remembering the source of words spoken by two speakers having the same gender than words spoken by a male or a female (Lindsay, Johnson, & Kwon, 1991, Exp. 1), differentiating previously performed actions when those actions possess functional similarity (Foley, Harris, & Hermann, 1994), and discriminating between memories of imagined and performed actions (e.g., Foley & Johnson, 1985).

Although much of the existing research has focused on the development of source monitoring in younger children (see reviews by Lindsay, 2008; Roberts, 2002), a number of studies have examined source monitoring in older children and adolescents (e.g., Cycowicz, Friedman, & Duff, 2003; Cycowicz, Friedman, Snodgrass, & Duff, 2001; Czernochowski, Mecklinger, Johansson, & Brinkman, 2005; de Chastelaine, Friedman, & Cycowicz, 2007; DeMaster & Gheiti, 2013; Gheiti, DeMaster, Yonelinas, & Bunge, 2010; Pathman, Samson, Dugas, Cabeza, & Bauer, 2011; Picard, Cousin, Guillery-Girard, Eustache, & Piolino, 2012).

Most of these studies have used behavioral paradigms in which older children and young adults were asked to differentiate the source of items that had been studied under two different, but similar, contexts. In each case, successful source memory performance required the retrieval of highly specific perceptual details, typically in the form of color information. For example, Czernochowski et al. (2005) examined item and source memory in younger children (6–8 years), older children (10–12 years), and adults (20–29). Participants were shown a block of photos, followed by a block of spoken words. Photos were shown on a red background, while words were presented along with a blue screen (or vice versa). Both item- and source-memory were tested with black line drawings. While adults performed better than the children on measures of item and source memory, the two groups of children did not differ from each other on either measure.

While the results of source monitoring studies are consistent with the notion that developmental differences may exist in controlled access to contextual details, they do not directly assess the notion that levels of retrieval specificity exist within tests of source memory, or that developmental differences in source memory increase when demands are placed on retrieval specificity. Retrieval specificity here refers to the fact that tasks vary in the extent to which they require access to specific information in memory, and that tasks requiring the recollection of more episodic detail place greater demands on the use of effortful, resource-demanding retrieval processes. Therefore, what is currently not known is the role that controlled retrieval has played in previous studies that have examined source memory in children and adolescents.

The Present Study

The purpose of the present study was to examine the role of controlled retrieval processes in the development of children's memory for context information. Specifically, the present study tested the hypothesis that developmental differences in recollection-based retrieval processes are not general in nature, but are a function of whether retrieval conditions place demands on the ability to access highly specific information. Within the present study, 'highly specific information' refers to the contextual details of an event (e.g., visual details, such as color), not the event itself. The current hypothesis is based on the assumption that the amount of cognitive control required to access detailed information may vary as a function of retrieval context. Given that controlled retrieval is resource demanding, such access should be sensitive to developmental differences. Support for this observation is provided by studies in which younger children exhibit greater difficulty differentiating memories containing similar source information than older children (Lindsay, 2008; Roberts, 2002). Critically, however, this hypothesis also predicts that such age differences in memory for context information may be reduced or eliminated by tasks that require less controlled retrieval, an important hypothesis that has yet to be tested. These predictions were tested in the present study by comparing memory for specific context details in children and adults under conditions that required varying amounts of controlled retrieval.

The design of this study was based on a recent investigation of the effects of retrieval specificity on adult age differences in recollection (Luo & Craik, 2009). Luo and Craik (2009, Experiment 1) asked younger and older adults to intentionally remember words from

each of three lists that presented items in a different context. One study list presented single words (“word only condition”); a second study list presented words along with a representative black-and-white drawing (“drawing condition”); and a third study list presented words with a corresponding color photo (“photo condition”). Memory for encoding context was subsequently tested with a series of brief recognition tests in which test items were presented as single words. For each test list, participants were presented with one of the following questions: (1) Was the word originally presented with a photo?, (2) Was the word presented with a line drawing?, or (3) Was it presented as a word alone? Each test list contained target items (i.e., words that had been studied in the condition being tested), distractors (i.e., words that had been studied, but were from a different condition), and new items (i.e., words that had not been presented previously). A “high specificity” and a “low specificity” test list was paired with each test question, with “high” and “low” specificity being determined by the nature of the distractors used in a test list. For example, for the test question, “Was the word originally presented with a photo?”, distractors in the “high specificity” condition consisted of non-target words that had been previously presented with line drawings, while distractors in the “low specificity” condition were non-target words that had been presented in the absence of an accompanying image in the preceding study phase. Although both low and high specificity tests required memory for context (e.g., “Was the word originally presented with a photo?”), performance on the high specificity tests increased the need for controlled access to visual details, such as color (Luo & Craik, 2009, p. 424). As noted by Luo and Craik (2009, p. 428), participants may be successful on low specificity tests merely by retrieving any pictorial information in the encoding phase. However, successful performance on high specificity tests requires the retrieval of more specific color information so as to allow one to distinguish between items that had been studied with drawings and items studied with photos.

Luo and Craik obtained estimates of recollection by employing the process dissociation procedure (Jacoby, 1991). Process dissociation assumes that recollection and familiarity exist independently and that estimates of each process may be derived mathematically. Recollection is estimated by subtracting the probability of selecting an item under an “exclusion” condition from the probability of selecting an item under an “inclusion” condition. By comparing performance on lists possessing identical list structures, Luo and Craik subtracted the probability of responding “yes” to a previously studied item when it should be rejected (exclusion condition) from the probability of responding “yes” to a previously studied item when it should be endorsed (inclusion condition). Luo and Craik found that the recollection of contextual detail was better in the low specificity than in the high specificity test condition for older but not younger adults. Specifically, when younger and older adults were asked to recollect contextual details under the conditions of low specificity test lists, no age differences were found. In contrast, when recollection of the same contextual details was tested under the conditions of high specificity tests, the memory performance of older adults was significantly lower than that of younger adults. Due to the similarities of targets and distractors in high specificity test lists, controlled access to the visual details of memory representations was more demanding in the high specificity than in low specificity test lists. As a result, Luo and Craik argued that the disproportionate decline in the memory performance of older adults on high specificity tests reflected increased

difficulties in the use of controlled retrieval processes that are needed when accessing contextual details of memory representations.

The present study examined whether children and young adults differ in their ability to use controlled retrieval processes to access the specific contextual details of memory representations. Nine year-old and 12 year-old children were included in this study in order to examine the developmental trajectory of controlled retrieval processes. These age groups were chosen because of the age-related improvements in controlled processing that have been found to occur throughout middle childhood (Schneider & Pressley, 1997). In addition, a number of investigators have found age-related improvements in source memory (e.g., Cykowicz et al., 2003; Czernochowski et al., 2005; DeMaster & Ghetti, 2013; Ghetti et al., 2010), as well as in the recollection-based retrieval processes of recognition memory (e.g., Billingsley et al., 2002; Brainerd et al., 2004; Ghetti & Angelini, 2008), during middle childhood and adolescence. Following the methods used in the Luo and Craik (2009) investigation, immediately following the presentation of words in three different study formats (i.e., words in isolation, words with a color picture, words with a black-and-white picture), participants were given a series of low and high specificity test lists. Assuming that the recollection of specific contextual detail is more demanding in high specificity test lists, each age group should exhibit relatively greater difficulty in the recollection of specific contextual details in high specificity than in low specificity test lists. Most importantly, given the developmental differences in controlled processing that appear during middle childhood, and to the degree that high specificity test lists place additional demands on controlled access to contextual details of memory representations, the performance of younger children should be disproportionately impaired in high specificity test lists. In contrast, because there are fewer demands on controlled access in low specificity test lists, developmental differences should be absent or greatly reduced. How the older children will perform, and whether their performance will be similar to that of younger children or adults, is uncertain. Regardless, finding developmental differences in the high, but not the low, specificity test lists would have theoretical significance by emphasizing the role of controlled retrieval processes in the recollection of contextual detail.

Method

Participants

Twenty-nine 9-year-olds ($M = 8.95$ years, $SD = .33$ years), 29 12-year-olds ($M = 11.95$ years, $SD = .31$ years), and 30 young adults ($M = 24.60$ years, $SD = 7.41$ years) participated in the experiment. There were 10 males and 19 females in the 9-year-old group, 9 males and 20 females in the 12-year-old group, and 7 males and 23 females in the young adult group. Children were recruited from a public elementary and a public middle school. None of the child participants were receiving special education services. The young adults were recruited from introductory psychology classes and received course credit for their participation.

Materials

The current experiment adopted the procedures used by Luo and Craik (2009). One notable exception is that the present study used color pictures as opposed to color photos in one

condition. This change was made in order to insure equivalency of stimulus characteristics (i.e., name agreement, visual complexity, and familiarity) across encoding conditions. For the present study, four lists of 36 words were created by selecting the modal names of pictures in Set 1 (Snodgrass & Vanderwart, 1980) of the norms of Cycowicz, Friedman, and Rothstein (1997). The four lists of words consisted of mono- or disyllabic nouns that were comparable in their mean frequency count for third graders (Means = 138.8, 102.1, 160, and 88.1) (Carroll, Davies, & Richman, 1971). A color picture representing each word was obtained from Rossion and Pourtois (2004). Using Photoshop CS5, a grayscale image of each color picture was also created by applying a photocopy filter to each color picture with a detail setting of 2 and darkness setting of 10. The four lists of pictures were equivalent in name agreement (Mean H statistic = .55, .49, .47, and .55) and in ratings of both visual complexity (Means = 2.77, 2.75, 2.66, and 2.75) and familiarity (Means = 2.77, 2.77, 2.75, and 2.72) in the norms of Cycowicz et al. (1997). Finally, each of the four 36-item lists had its own buffer items (four at the beginning of the list and four at the end) that were selected from the norms of Cycowicz et al. (1997). Buffers are noncritical items that are designed to eliminate the possibility of primacy and recency effects.

The four lists were used during the study and test phases of the task. Three of the four lists and their corresponding buffer items were presented during the study phase: One list presented words alone, without an accompanying picture; a second list presented individual words with their color pictures; and a third list presented words with their corresponding black-and-white pictures. The presentation order of the three study-lists, and the 36 critical items that comprised each study list, were randomized anew prior to their presentation to each participant. The 36 critical words from the fourth list were used as new items in the subsequent test phase of the task. Within each group of participants, each of the four lists was presented about equally often as one of the four item-types (i.e., words alone, color, black-and-white pictures, and new items).

Words from the four lists were selected randomly to construct six 24-item test lists. Table 1 provides an overview of the six test-lists. Each test list contained 18 previously studied (old) words (nine words from each of two different study lists) and six new words from the unstudied list. Items in the test lists were presented as words without an accompanying picture. Depending on the test, participants were asked one of three questions: “Did you study this word with a black-and-white picture?”; “Did you study this word alone, without a picture?”; or “Did you study this word with a color picture?”. Two test-lists consisting of targets, new items, and distractors were constructed for each of the three test-questions.

Central to the design of this experiment was the manipulation of the type of distractors used in the two test-lists that were paired with a given test question. For example, in the two test-lists that were paired with the test question, “Did you study this word with a color picture?”, one test-list contained distractors that were selected from the “word alone” study condition, whereas the second test-list consisted of distractors that were obtained from the “black-and-white picture” study condition. In this example, the test list containing distractors from the “word alone” study condition represented a “low specificity” test, while the test list consisting of distractors from the “black-and-white picture” study condition represented a “high specificity” test. The 18 old items on the “high specificity” test lists included nine

words that had been presented previously with a color picture, and nine words that were presented with a black-and-white picture. Thus, participants were required to recollect specific information from the initial encoding experience (color pictures) in the context of old, nontarget items containing similar, but noncritical, features (black-and-white pictures). The 18 old items on “low specificity” tests lists included nine items that had been previously presented with an image (either color or black-and-white), as well as nine items that were studied as words only. In this case, participants were required to remember specific information from the initial encoding experience (e.g., color pictures) in the presence of old, nontarget items that were less similar (words alone). Note that in Table 1 there are only low specificity test lists when the participant is asked, “Did you study this word alone, without a picture?”. Due to the nature of the question and the design of this experiment, there is no high specificity test list associated with this question. The presentation order of the six test-lists and their corresponding items were randomized anew for each participant.

The composition of the six test-lists allows one to obtain estimates of recollection by applying the process dissociation procedure (Jacoby, 1991). Across the six test-lists, there were pairs of lists that had the same list structure (e.g., lists constructed with “color” items, “word” items, and “new” items), but appeared with different test questions. So, depending on how a word was studied (e.g., the word, “cap,” may have been presented with a color picture), and how the word was paired with a test question, a given item should be endorsed (inclusion condition) or rejected (exclusion condition). Continuing with the above example, the word “cap” should be endorsed if it was paired with the test question, “Did you study this word with a color picture?”, but rejected if it appeared with the test question, “Did you study this word alone, without a picture?”.

Additional words and pictures were selected from Cycowicz et al. (1997) and Rossion and Pourtois (2004) to construct a brief practice activity that was designed to familiarize participants with the task and its requirements. The practice task consisted of three 4-item study lists: List one presented words that were accompanied by a color picture; list two presented words with a corresponding black-and-white picture; and list three presented words alone. Three 5-word test lists were presented, with each test containing a different question: “Was this word presented with a color picture?”; “Was this word presented with a black-and-white picture?”; or “Was this word presented alone?”. Each of the practice tests presented two old items in which “yes” was the correct response, two old items in which “no” was the correct response, and one completely new item in which “no” was the correct response. For example, with the practice test that asked the question, “Was this word presented with a color picture?”, two old words were presented that had been presented previously with a color picture (“yes” was the correct response), one old word was presented with a black-and-white picture (“no” was the correct response), one old word was presented as a solitary word (“no” was the correct response), and one new word (“no” was the correct response).

Procedure

Participants were tested individually in a quiet room in the presence of an experimenter. Participants were told that they would be presented with three lists of words on the computer

monitor: One list would present words one-by-one with a color picture; a second list would present additional words, but with a black-and-white picture; and a third list would present other words by themselves without any pictures. Participants were told that their task was to try to remember the words and how the words were presented to them: “Try your best to remember which words are presented with color pictures, which words are presented with black-and-white pictures, and which words are presented by themselves (without pictures).” Participants were informed that they would later be given some memory tests that ask them to remember whether they saw individual words, and if so, how the words were presented (i.e., with a color picture, with a black-and-white picture, or word alone).

Following the general instructions, each participant was given the practice task. Practice stimuli were presented sequentially on individual pages of a 21.59 cm × 13.97 cm sketchbook. Three 4-item study lists were presented in the following order: (1) words with color pictures, (2) words with black-and-white pictures, and (3) words alone. Prior to each study list, the experimenter provided the participant with the relevant instruction (e.g., “Remember that the following words appear with a color picture.”). Each study list word was read aloud by the experimenter and presented for approximately 3 sec. Following the presentation of final study list, three 5-item test-lists were presented to the participant. Each item in a given test was accompanied by a typewritten question that appeared at the top of each page: “Did you study this word with a black-and-white picture?” (Test 1); “Did you study this word alone, without a picture?” (Test 2); and “Did you study this word with a color picture?” (Test 3). Each test word and its corresponding test question were read aloud by the experimenter. Participants were asked to provide a “yes” or “no” response and were given immediate feedback about the accuracy of their response. The experimenter recorded the accuracy of each subject’s responses. The mean number of correct responses on the 15-item practice task was comparable across the three age-groups ($M_s = 13.8, 13.9, \text{ and } 13.9$ for 9-year-olds, 12-year-olds, and young adults, respectively), suggesting that the three groups possessed a similar understanding of the task and its requirements. Upon completion of the practice task, participants were told that none of the practice words or pictures would be presented in the forthcoming memory task.

E-Prime software (Schneider, Eschman, & Zuccolotto, 2002) was used to present stimuli and record response accuracy on a Dell laptop computer during the experimental task. For the initial study phase, words and (depending upon the nature of the study list) their corresponding pictures were presented in the center of the computer monitor using a 3s exposure duration. For those study trials that also presented pictorial information, words and pictures were presented simultaneously, with the picture appearing directly above the word. For both study and test trials, each word was presented using an audio-visual format that synchronized the presentation of its visual (i.e., 14-point, lowercase Arial font) and auditory (i.e., pre-recorded in a WAV file using an adult female voice) information. Depending on the nature of the study list, the participant was instructed at the beginning of each list to “Remember that the following words appear with color pictures,” “Remember that the following words appear with black-and-white pictures,” or “Remember that the following words appear alone, without any pictures.”

Immediately following the presentation of the final study list, the six 24-item tests, representing two tests for each of the three study-list conditions, were randomly presented. Participants were not informed about the characteristics of items comprising each test list. Each of the six tests began with a question that was relevant to that test (e.g., “Did you study the following words with a color picture?”). Individual test words appeared in the center of the screen on each trial, along with its test question at the top of the screen (e.g., “Did you study this word with a color picture?”). The experimenter read aloud the test question at the top of the screen during the first several trials to assure that participants attended to the appropriate test question. Participants were instructed to respond to each test question by pressing one of two keyboard keys labeled *YES* (P key) or *NO* (Q key) using their index fingers (left index finger for *Yes* responses and right index finger for *NO* responses). Participants completed each of the six tests at their own pace.

Data Analysis

Following Jacoby’s (1991) process dissociation procedure, estimates of recollection were computed by subtracting exclusion performance from inclusion performance. Inclusion performance was defined as the probability of correctly responding “yes” to a studied item when it should be endorsed (e.g., responding “yes” to a previously studied word + color picture item when presented with the test question, “Did you study this word with a color picture?”). Exclusion performance was defined as the probability of incorrectly responding “yes” to a studied item when it should *not* be endorsed (e.g., incorrectly responding “yes” to a previously studied word + color picture item when presented with the test question, “Did you study this word with a black-and-white picture?”). Baseline false alarm rates were defined as the probability of responding “yes” to new items. For all participants, measures of inclusion and exclusion performance were adjusted by subtracting their baseline false alarm rates from their measures of inclusion and exclusion performance in order to correct for any general bias to respond “yes” to a new item.

Measures of inclusion and exclusion performance were used to compute six estimates of recollection for each participant: (1) color picture/low specificity, (2) color picture/high specificity, (3) black-and-white/low specificity, (4) black-and-white/high specificity, (5) word alone in a test list with color pictures, and (6) word alone in a test list with black-and-white pictures. Each of the six recollection scores was calculated by comparing performance on pairs of test lists that contained words that were studied in the same contexts, but were tested in the context of different questions. For example, recollection scores for the color picture/low specificity condition (i.e., words studied with color pictures and tested in the low specificity test condition) were computed by contrasting the probability of responding “yes” on two lists possessing identical structure (i.e., each list contained words that had been studied with color pictures, words studied alone, and new words). However, the two test-lists were presented in the context of different questions, with one test asking, “Did you study this word with a color picture?”, and the second test asking, “Did you study this word alone, without a picture?”. In this example, when presented with the test question, “Did you study this word with a color picture?”, the *inclusion score* is represented by the probability of *correctly* responding “yes” to a word that had been previously studied with a color picture. On the other hand, when presented with the test question, “Did you study this word alone,

without a picture?”, the *exclusion score* is reflected in the probability of *incorrectly* responding “yes” to words that were previously studied with a color picture. Recall scores were calculated as the difference between inclusion and exclusion performance. Thus, when presented with the test question, “Did you study this word with a color picture?”, if a participant *correctly* responded “yes” to test words that had been previously studied with a color picture 75% of the time, his or her *inclusion* score would be .75. On the other hand, when presented with the test question, “Did you study this word alone, without a picture?”, if the participant *incorrectly* responded “yes” to test words that were previously studied with a color picture 25% of the time, his or her *exclusion* score would be .25. Without adjusting for baseline false alarm rates, this participant’s recollection score in the color picture/low specificity condition would be .50 (inclusion score minus exclusion score).

Results

Tables 2 and 3 provide, respectively, the mean probability of providing a “yes” response on low and high specificity test-lists according to age group, test question, and encoding condition. The initial analysis examined whether the recollection of words studied without a picture varied as a function of age group and test context (i.e., tested in the context of color or black-and-white pictures). Following their logic and based on the results provided by Luo and Craik (2009), there was no reason to expect differences in the recollection of words studied alone that were tested along with color or black-and-white pictures. As noted by Luo and Craik (2009, p. 426), performance under such conditions may be based merely on whether a given test item was presented with an image. As such, remembering whether a test item had been studied with or without an image represents a low level of retrieval specificity. The recollection scores of items studied as words alone were submitted to a 3 (Age Group: 9-year-olds, 12-year-olds, young adults) X 2 (Test Context: Color Picture vs. Black-and-White Picture) mixed design Analysis of Variance (ANOVA), with Age Group as the between subjects factor and Test Context as the within subjects factor. There was no effect of Age Group, $F < 1$, or Test Context, $F(1,85) = 2.37$, $MSE = .097$, $p > .14$, nor did they interact, $F < 1$. In addition, there was no effect of Age Group on inclusion scores, $F < 1$, exclusion scores, $F < 1$, or new items, $F(2,85) = 1.036$, $MSE = .022$, $p > .35$, for words that had been studied alone.

The next set of analyses examined whether the recollection of words studied with color pictures or black-and-white pictures varied with age group or the context specificity of the test. Recollection scores were submitted to a 3 (Age Group: 9-year-olds, 12-year-olds, young adults) X 2 (Encoding Context: Color Picture vs. Black-and-White Picture) X 2 (Test Specificity: Low vs. High) mixed design ANOVA, with Age Group as the between subjects factor and Encoding Context and Test Specificity as the within subjects factors. The effect of Encoding Context was significant, $F(1,85) = 9.721$, $MSE = .213$, $p = .002$, $h_p^2 = .103$, indicating that words studied with color pictures ($M = .530$) produced higher recollection scores than words studied with black-and-white pictures ($M = .376$). The effect of Test Specificity was significant, $F(1,85) = 73.830$, $MSE = .092$, $p < .0001$, $h_p^2 = .465$, and interacted with Age Group, $F(2,85) = 4.022$, $MSE = .092$, $p = .021$, $h_p^2 = .087$. The Test Specificity X Age Group interaction is displayed in Figure 1, which shows the recollection scores (collapsed across Encoding Context) of each age group on low and high specificity

tests. Follow-up analysis of this interaction examined the effect of Age Group separately at Low and High levels of Test Specificity. Although there was no effect of Age Group on recollection scores at the Low level of Test Specificity, $F(2,85) = 1.01$, $MSE = .095$, $p > .36$, there was a significant effect of Age Group at the High level, $F(2,85) = 4.881$, $MSE = .045$, $p = .01$, $h_p^2 = .103$. Post hoc tests (Tukey) indicated that 9-year-olds ($M = .215$, $SD = .031$) produced significantly lower recollection scores than both 12-year-olds ($M = .375$, $SD = .055$) and young adults ($M = .352$, $SD = .049$), but that the latter two age groups did not differ from each other.

Supplementary analyses were performed to further illuminate the age differences that were observed in the recollection scores on tests with High levels of Test Specificity. Three t -tests were conducted that compared 9-year-olds with young adults on (1) hits (e.g., the probability of correctly responding “Yes” to a previously studied word + color picture item when presented with the test question, “Did you study this word with a color picture?”); (2) false alarms to distractors (e.g., the probability of incorrectly responding “yes” to a previously studied word + black-and-white item when presented with the test question, “Did you study this word with a color picture?”) and (3) baseline false alarm rate (e.g., the probability of incorrectly responding “yes” to a new word when presented with the test question, “Did you study this word with a color picture?”). In each case, the analyses collapsed across question type (i.e., “with color drawing?” or “with black-and-white drawing?”). There were no age differences in the probability of responding “Yes” to target items, $t(57) = 1.447$, $p > .15$, or new items, $|t| < 1$. However, compared with young adults ($M = .257$, $SD = .023$), 9-year-olds ($M = .337$, $SD = .02$) were significantly more likely to respond “Yes” to old/non-targets, $t(57) = -2.074$, $p = .043$, $h^2 = .070$. The results of these supplementary analyses indicate that 9-year-olds experienced particular difficulty when attempting to differentiate targets and old/non-targets (e.g., color picture/target vs. old black-and-white/non-target) on high specificity tests.

Discussion

The present study tested the hypothesis that developmental differences in recollection-based retrieval processes are not general in nature, but are a function of whether retrieval conditions place demands on the ability to access highly specific information. This hypothesis was based on several assumptions contained within the representation and control framework of Craik and Bialystock (2006). First, memory representations are presumably structured in a hierarchical manner, with information being arranged in a general-to-specific manner. Second, tasks that require access to context-specific representations place greater demands on controlled processing than tasks that require access to representations containing less specific information. Third, control systems operating on representational systems improve during childhood and decline during the adult aging process. Given these assumptions, it follows that children should improve in their ability to use controlled retrieval to access specific details of memory episodes as they grow older they. Luo and Craik (2009) provided evidence that, relative to younger adults, older adults have greater difficulty using controlled retrieval processes to access detailed information in memory. By extension, the current study examined whether children and young adults differ in their ability to recollect highly specific forms of information. When compared with their

performance on less demanding low-specificity tests, all age groups experienced greater difficulty on high-specificity tests that placed greater demands on the ability to access the specific contextual details of study list items. More importantly, relative to 12-year-olds and young adults, the performance of 9-year-olds was disproportionately lower on high-specificity tests that placed demands on the ability to access the specific contextual details of study items. In contrast, age differences in recollection were notably absent on low-specificity tests that placed fewer demands on the ability to access specific context information. These results are consistent with the position that representations have different levels of specificity (Craik, 2002), and that developmental differences exist in the control systems that act on those representations (Craik & Bialystock, 2006). As with older adults (Luo & Craik, 2009), younger children appear to have a deficit in the controlled retrieval of specific contextual information.

The current study was based on the observation that source memory and episodic memory share common processes (Johnson et al., 1993). Because of shared processes, source memory tasks may provide a unique way of investigating some of the qualities of episodic memories (Johnson, 2005). By using a source memory task that manipulated demands on the controlled retrieval of detailed context information, the current study has yielded important information about the development of recollection-based retrieval processes. As previously noted, a variety of studies have consistently found that recollection-based memory processes improve throughout middle childhood on recognition memory tasks (Billingsley et al., 2002; Brainerd et al., 2004; Defeyter et al., 2009; Friedman et al., 2010; Ghetti & Angelini, 2008; Holliday, 2003; Holliday & Hayes, 2000, 2001; Ofen, et al., 2007; Rhodes et al., 2011). The results of the present study indicate that developmental improvements in such recollection-based processes are not general in nature. If age differences in recognition memory were based solely on a more general maturation of recollection-based retrieval processes, one would have expected age-related improvements on both low and high specificity tests. Yet, developmental differences in recollection-based retrieval processes depended on the extent to which recollection required the use of more controlled retrieval processes. When there were fewer demands placed on the retrieval of specific information, there were no age differences in recollection. However, when the retrieval task placed a premium on a finer-grained analysis of memory representations, developmental differences emerged in recollection. Thus, the pattern of results found in the current study suggests that age differences in recollection of detailed information are apt to appear only when the retrieval environment places sufficient demands on the use of more effortful, controlled retrieval processes. This conclusion is consistent with Craik's (2002) observation that it is not memory systems or forms of memory per se that are sensitive to age differences, but whether tasks place demands on the self-initiated use of certain processing operations. In the case of the present study, we believe that younger children lacked the necessary control that would have allowed them to access memory traces from specific sources.

Noteworthy is that developmental differences in recollection were manifested as the result of manipulating the retrieval context of recognition tests. Unlike source monitoring studies that often manipulate the similarity of context during encoding (e.g., a list of items presented by two speakers of the same gender vs. a list of items presented by a male and a female), the present study manipulated retrieval context by using both low and high specificity test lists.

Low specificity tests presented words that had been studied alone or with one of the two images (e.g., black-and-white pictures), whereas high specificity tests consisted of words that had been studied with images (i.e., black-and-white pictures or color pictures). These subtle changes in the composition of low and high specificity test lists were designed to make differential demands on retrieval processes. Low specificity lists placed fewer demands on controlled access to contextual detail, whereas high specificity tests placed greater demands on controlled access to more specific information in memory. Although the performance of younger children in the present study parallels that of children in previous source monitoring studies (see reviews by Lindsay, 2008; Roberts & Blades, 2000), there is an important difference between the present study and previous ones. In previous studies developmental differences in source memory were present when the context information associated with study list items was similar, yet absent when such information was dissimilar (e.g., Foley & Johnson, 1985; Lindsay et al., 1991, Exp. 1). In contrast, the results of the present study indicate that recollection of context information can be modulated by changes in the retrieval environment, even when the similarity of context information is held constant. In particular, the present study has demonstrated that developmental differences are expressed only when the test presents the effortful, resource-demanding task of accessing the contextual details of memory representations. In contrast, the results obtained with low specificity tests indicate that developmental differences in the recollection of context information may be eliminated by a different retrieval environment, one that places fewer demands on controlled retrieval processes. Note that this was the case, even though participants had to make source judgments about highly similar information. Therefore, the findings of the present study provide an important contribution by showing that developmental differences in source memory can be affected by a factor that specifically places demands on one's ability to control retrieval. Consequently, the results of the present study demonstrate the role of controlled retrieval in the developmental differences in source memory.

Luo and Craik (2009) observed that the disproportionate decline of recollection scores on tasks demanding access to highly specific forms of context information may be explained by combining Craik's hierarchical model with Jacoby's recent conceptualization of controlled retrieval (Jacoby, Shimizu, Daniels, & Rhodes, 2005; Jacoby, Shimizu, Velanova, & Rhodes, 2005). Recall that Craik's hierarchical model organizes memory representations on a continuum of specificity, ranging from representations of specific experiences, rich in contextual detail, to those containing general information, devoid of context. Jacoby and his colleagues (Jacoby, Shimizu, Daniels, et al., 2005, p. 852) note that recognition memory may involve "*source-constrained retrieval* – the self-initiated use of source information to constrain what comes to mind during retrieval." In contrast to a post-access monitoring process that edits potential responses *after* they come to mind, source-constrained retrieval "allows only memories from a questioned source to come to mind" (Jacoby, Shimizu, Daniels, et al., 2005, p. 853). Luo and Craik (2009) suggest that retrieval is constrained in two ways in their paradigm. One constraint is the goal of remembering the source of studied items during each recognition memory test (e.g., "Did you study this word with a color picture?"). The second constraint for retrieval is the composition of test lists where the characteristics of target and non-target items provide a "'global' context and background for

retrieval” (Luo & Craik, 2009, p. 433). Because the encoding contexts of target and non-target items on high specificity tests are similar (e.g., words studied with a black-and-white picture or a color picture), access to the original encoding context must be highly constrained in order to remember whether an item was presented with a color picture. In contrast, the demand on source-constrained retrieval is reduced on low specificity tests where target and non-target items are dissimilar (e.g., words studied alone or with a black-and-white picture). Given these observations, the disproportionate difficulties of 9-year-olds on high specificity tests may be based on a less constrained use of source information. On the other hand, 12-year-olds and young adults presumably used background context of other list items on high specificity tests to further constrain the retrieval of source information. Additional research is needed that formally examines the cognitive control of retrieval processing in younger and older children, and whether there are developmental improvements in the ability to constrain retrieval “such that only sought after information comes to mind” (Jacoby, Shimizu, Velanova, et al., 2005, p. 493). Given that source constrained retrieval appears to pose a problem with older adults, it may be another mechanism that is sensitive to life-span developmental differences.

Although the focus of this discussion has been on developmental differences in the controlled retrieval of detailed context information, it is important to emphasize that age differences were absent on tasks requiring the recollection of specific information, but in a context that placed fewer demands on controlled retrieval (i.e., low-specificity tests). Because of differences in the nature of non-target items, the retrieval environment of low-specificity tests in a sense provided a higher level of support than high-specificity tests. These differences in the construction of test lists represent different levels of “environmental support” (Luo & Craik, 2008), and suggest that developmental differences in retrieval may be reduced or eliminated when aspects of a test compensate for processing operations that are not utilized spontaneously by younger children. The observation that recollection varies with the demands of the retrieval context resonates with Ornstein et al.’s (Folds, Footo, Guttentag, & Ornstein, 1990; Ornstein & Myers, 1996; Ornstein & Light, 2010) use of the term, “context specificity,” to describe contextual variations in children’s memory performance. Based on the observation that variations in task conditions often affect children’s use of memory strategies, Ornstein and his colleagues used the term, “context specificity,” to characterize the memory performance of children. Context specificity acknowledges that conclusions about “children’s abilities vary markedly as a function of both the materials that are to be remembered and the prevailing assessment conditions” (Ornstein & Myers, 1996, p. 212). Thus, children may exhibit more mature strategies in highly supportive settings, but not in others (Ornstein & Light, 2010).

Acknowledgments

The authors thank Heather Clark, Allie Stangl, Kirsten Voigt, and Samantha Zabawa for their help with data collection.

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Figure 1. Mean recollection scores as a function of Age Group and Test Specificity. Error bars show standard errors.

Table 1

Composition of the Six Test-lists.

Test question	Retrieval Specificity	Encoding context ^a	Correct response
“Did you study this word with a color picture?”	Low	Color picture (9)	Yes
		Word alone (9)	No
		New (6)	No
	High	Color picture (9)	Yes
		Black-and-white picture (9)	No
		New (6)	No
“Did you study this word with a black-and-white picture?”	Low	Black-and-white picture (9)	Yes
		Word alone (9)	No
		New (6)	No
	High	Black-and-white picture (9)	Yes
		Color picture (9)	No
		New (6)	No
“Did you study this word alone, without a picture?”	Low	Word alone (9)	Yes
		Color picture (9)	No
		New (6)	No
	Low	Word alone (9)	Yes
		Black-and-white picture (9)	No
		New (6)	No

^aThe numerals beside each entry indicate the number of items contained in that test list.

Table 2

Mean Probability of Responding “Yes” in Low Specificity Test Lists as a Function of Age Group and Test Question for Each Encoding Condition.

Test Question	Age Group					
	Nine-year-olds			Twelve-year-olds		
	<i>M</i>	<i>SD</i>		<i>M</i>	<i>SD</i>	Young adults <i>M</i> <i>SD</i>
With color picture?						
Color picture ^a	0.65	0.19	0.59	0.20	0.65	0.17
Word alone ^b	0.13	0.14	0.21	0.19	0.17	0.17
New ^c	0.07	0.13	0.05	0.09	0.06	0.09
With black-and-white picture?						
Black-and-white picture ^a	0.62	0.13	0.64	0.20	0.55	0.17
Word alone ^b	0.18	0.18	0.21	0.15	0.20	0.18
New ^c	0.11	0.16	0.08	0.15	0.08	0.11
Word alone, without a picture?						
Word alone ^a	0.49	0.19	0.63	0.19	0.63	0.26
Color picture ^b	0.22	0.17	0.21	0.16	0.25	0.19
New ^c	0.26	0.25	0.38	0.31	0.27	0.26
Word alone, without a picture?						
Word alone ^a	0.58	0.23	0.64	0.22	0.60	0.23
Black-and-white picture ^b	0.27	0.20	0.28	0.17	0.25	0.17
New ^c	0.27	0.34	0.28	0.29	0.22	0.22

Note:

^aThese values reflect the probability of a correct response; i.e., the probability of correctly responding “yes” to a studied item when it should be endorsed (inclusion performance);

^bThese values reflect the probability of a false alarm; i.e., the probability of incorrectly responding “yes” to a studied item when it should **not** be endorsed (exclusion performance);

^cThese values reflect the probability of a false alarm; i.e., the probability of responding “yes” to a new item when it should **not** be endorsed (baseline false alarm rates)

Table 3

Mean Probability of Responding “Yes” in High Specificity Test Lists as a Function of Age Group and Test Question for Each Encoding Condition.

Test Question	Age Group					
	Nine-year-olds			Twelve-year-olds		
	<i>M</i>	<i>SD</i>		<i>M</i>	<i>SD</i>	<i>M</i>
With color picture?						
Color picture ^a	0.58	0.18	0.71	0.20	0.63	0.20
Black-and-white picture ^b	0.40	0.20	0.26	0.20	0.29	0.23
New ^c	0.13	0.19	0.09	0.11	0.11	0.18
With black-and-white picture?						
Black-and-white picture ^a	0.52	0.20	0.59	0.19	0.59	0.19
Color picture ^b	0.28	0.16	0.28	0.19	0.23	0.19
New ^c	0.12	0.18	0.14	0.18	0.12	0.14

Note:

^aThese values reflect the probability of a correct response; i.e., the probability of correctly responding “yes” to a studied item when it should be endorsed (inclusion performance);

^bThese values reflect the probability of a false alarm; i.e., the probability of incorrectly responding “yes” to a studied item when it should *not* be endorsed (exclusion performance);

^cThese values reflect the probability of a false alarm; i.e., the probability of responding “yes” to a new item when it should *not* be endorsed (baseline false alarm rates)