ABSTRACT

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Emotion can be characterized in terms of valence and arousal. Both of these dimensions enhance memory in adults by specifically enhancing a form of memory called recollection. Recollection is required for memory of source or encoding context, and shows prolonged development throughout childhood. The specific effects of valence and arousal on memory, and specifically on recollection, have thus far not been studied developmentally. The current study examined how valence and arousal affect memory in 8-year-olds, using a source memory paradigm that allowed for the examination of emotion effects on recollection. Results showed that, after statistically controlling for effects of age, valence enhanced memory for items, but not source, and that there were gender differences in the effects of arousal on source memory, with girls showing better performance in the high-arousal condition and boys showing better performance in the low-arousal condition.

THE EFFECTS OF VALENCE AND AROUSAL ON ITEM AND SOURCE MEMORY IN CHILDHOOD

By

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Chapter 1: Introduction

Memory has been described as “mental time travel” (Tulving, 1983). Emotion endows events with personal significance, making us more likely to journey to the times, places and events that are emotionally weighted and thus have the greatest significance to us (Reese, Newcombe & Bird, 2006). For example, there is evidence that when adults report their earliest memories, they tend to be emotionally valenced (Howes, Seigel, & Brown, 1993; Kihlstrom & Harakiewicz, 1982). The reasons for this remain to be fully elaborated. It may be that all memories are initially created equal, but as we age, these are the memories that “stay with us”, or it may be that emotion enhances memory starting in childhood, so that emotional memories are stronger from the beginning.

There is considerable evidence from experimental paradigms indicating that emotion enhances memory from the start in adults, and that this is primarily due to its effects on a form of memory called recollection (e.g., Dolcos, Labar, & Cabeza, 2005; Kensinger & Corkin, 2003b). Recollection is described in dual-process models as a form of memory (termed a process) that incorporates contextual details about when and where an item was previously encountered, which can be contrasted with familiarity, which entails recognition without the retrieval of context (Yonelinas, 2002). Dual-process models will be discussed in greater detail below.

Although ample empirical research on this topic exists for adults, controlled studies examining the effects of emotion on memory in childhood are rarer. One may assume that the effects of emotion are the same across the lifespan, but there are dramatic differences in both overall memory ability and the organization of memory in children and adults. For example, recollection and familiarity have been shown to follow different developmental trajectories (Ghetti & Angelini, 2008), with recollection developing more slowly. Results such as these raise the possibility that the effects of emotion on memory may change in non-obvious ways across development. In addition, because of these developmental changes in recollection over the course of childhood, the mechanisms through which emotion impacts memory may also vary.

Some research exists on the effects of emotion on memory in childhood (as opposed to retrospective studies in which adults report childhood memories). However, little has been done in a controlled laboratory setting. The studies that have been conducted have not allowed for the examination of specific forms of memory (i.e., recollection and familiarity) involved in children's performance. This question is of interest to both basic scientific research and clinical research as it may have implications for conditions in which emotion plays a strong role, such as anxiety (e.g., Daleiden, 1998), depression (e.g., Bishop, Dalgliesh, & Yule, 2004), or post-traumatic stress disorder (PTSD, e.g., Moradi, Taghavi, Neshat-Doost, Yule, & Dalgleish, 2000).

The current study examined the effects of emotion on memory in children in a controlled laboratory setting using a source memory paradigm. This paradigm is distinctive in that it is designed to allow for the examination of the effects of emotion on specific forms of memory (i.e., recollection and familiarity). In order to explain the motivation for this study, I will briefly review the relevant literature on emotion and memory in adulthood and childhood. I will next review the general literature on recollection and familiarity, which are posited to underlie episodic memory, followed by a discussion of what is known about how they are involved in the effects of emotion on memory. I will then discuss the development of recollection in childhood. Finally, I will present the current study, which was designed to examine the effects of emotion on memory, and specifically on recollection, in children.

Memory and Emotion

One famous emotion researcher has described emotion as "the physiological and motor responses, the thoughts, images and information processing, and the mobilization of efforts to cope with the source of emotion," (Ekman, 1989, p. 159). Others (e.g., Keltner & Lerner, 2010; Russell, 2003) have found it more difficult to define. Nonetheless, emotion is often conceptualized in terms of pleasure-displeasure (valence) and degree of arousal (low-high, Bradley, Greenwald, Petry, & Lang, 1992; Mehrabian & Russell, 1974; Russell, 1980). These two dimensions (valance and arousal) are subjectively different and have also been shown to engage different neural circuitry (Dolcos, LaBar & Cabeza, 2004; Kensinger & Corkin, 2003a), suggesting there are qualitative differences between them and that both represent meaningful yet distinct ways to classify emotional responses.

In adults, there is considerable evidence that memory for emotional material is special. This section is not meant to be exhaustive (for reviews, see Christiansen, 1992; Hamann, 2001; Levine & Pizarro, 2004) but is meant to provide context and background on the methods used and findings related to emotion memory. Emotional memory involves physiological pathways beyond those involved in non-emotional memory (for reviews, see LaBar & Cabeza, 2006; McGaugh & Cahill, 2003).

Emotional memories engage structures in the medial temporal lobe, including the hippocampus, which are necessary for all episodic memories, but also the amygdala, which is specifically involved in memory for emotionally arousing material (Adolphs, Cahill, Schul, & Babinsky, 1997; Adolphs, Tranel, & Denburg, 2000; Kensinger & Corkin, 2003a). In addition, there is evidence that the effects of valence on memory involve connections between the pre-frontal cortex (PFC) and hippocampus (Kensinger & Corkin, 2003a).

Attempts have been made to dissociate the impact of arousal and valence. Bradley et al. (1992) examined the effects of both valence and arousal on memory using a free-recall task. They found that, regardless of valence, high arousal pictures were remembered better than low-arousal pictures, and that this effect was significant at both immediate and delayed recall. Valenced pictures were remembered better than neutral pictures at immediate, but not delayed, recall. In a study using a cued-recall task and fMRI, Dolcos et al. (2004) found that arousal enhanced memory, and that positive and negative pictures were both better-remembered than neutral pictures. They also found that arousal and valence had dissociable effects on brain activation in specific regions of the PFC at encoding. Bradley and Lang (2000) examined memory for emotional and neutral sounds. They found better recall for highly arousing sounds as well as improved memory for both positively and negatively valenced sounds. However, the sounds in both valence conditions were more arousing than the neutral sounds, and further analysis indicated that while valence may have played a role, arousal made a greater contribution to enhancing memory.

Overall, it appears that both valence and arousal are involved in enhanced memory in adults, and that arousal may play the larger role. However, this dissociation is difficult to make as valenced stimuli are often also more arousing than neutral stimuli, producing a confound that is hard to disentangle. Nonetheless, it is clear that in adults, emotion does enhance memory.

As described above, the adult literature provides many examples of laboratory-based measures of emotion memory, but such methodology has seldom been applied to children. Instead, much of the work on the effects of emotion on children's memory has employed methods that examine memory for real-life emotional events, such as medical procedures, rather than laboratory-encoded stimuli. For example, Quas, Goodman, Bidrose, Pipe, Craw, and Ablin (1999) asked children aged between 3 and 13 years about their memories of a previously-experienced painful and embarrassing medical procedure (a voiding cystourethrogram fluoroscopy or VCUG) experienced between the ages 2 and 6 years old, at delays of between 8 months and 5 years 9 months. A variety of measures including free recall, a doll and props demonstration, and direct questions were employed. Children's answers were compared to medical records, standard information about the procedure, and parent reports about their child's experience. Children older than 4 years at the time of the procedure gave more information at free recall than did children who were younger than 4 at the time. A similar effect was seen for children for whom the delay between the procedure and the interview was shorter. Similarly, Chen, Zelter, Craske, and Katz (2000) assessed children's memories for a different painful procedure (lumbar puncture) after a 1-week delay. Children were first presented with broad, open-ended questions about the procedure, followed by specific yes-no questions. Questions focused on details about the procedure, such as the length of the needle used, how long the procedure took, what materials were used to clean their back and the setting in which the procedure occurred, such as what furniture was in the room and who was in the room. They also asked questions about the child's emotional responses. Children's responses were coded to give scores for the number of questions answered correctly. Younger children's (ages 3 to 7 years) memory performance was significantly worse than that of older children (ages 11 to 18 years), with older children remembering more details about the procedure, suggesting age-related improvements in memory for emotional events.

The above studies show that young children can remember emotional experiences involving pain. There is also evidence to suggest that these memories are robust and are remembered years later. Peterson (1999) assessed children's memories for injury requiring hospital treatment 2 years after the event. Children were recruited at their visit to the emergency room at between ages 2 and 13 and visited at home a week later. During this visit, children and parents were interviewed separately about the injury and treatment. Children were interviewed again at 6 months, 1 year and 2 years later. Older children recalled more features than did younger children. Peterson and Whalen (2001) found a similar pattern in children's memories for a medical emergency five years after the hospitalization. Children's recall was scored for completeness and accuracy, and results indicated that memory was better for central (i.e., related to their injury) than for peripheral (i.e., related to the treatment) features of the event, and that overall memory for the event was quite good.

Children aged 2 at the time of injury were significantly less complete and accurate in their reports than those aged 8 to 9. Children who were 3 to 4 years old at time of injury were significantly less complete and accurate than those who were 8 to 9 years old. Five to 6-year-olds were significantly less complete and accurate than 12 to 13-year-olds. While adjacent groups did not significantly differ from each other, overall older children showed better memory than did younger children, and the effect was incremental.

Although these studies allowed for the examination of children's memory for emotional life events, they also point to the need for further study in a laboratory-based setting. These studies are high in ecological validity and suggest age-related improvement in memory for emotional events, but they do not allow for comparison between emotional and non-emotional memory. Furthermore, they can tell us little about the relative contributions of recollection and familiarity to developmental change in emotion memory. Laboratory-based measures are needed in order to answer these questions. The following paragraphs provide examples of such studies of emotion memory in childhood.

Laboratory-based studies of emotion memory in typically-developing children have often presented a story, either visually or verbally, and compared memory for emotional and neutral material presented. Bugental, Blue, Cortez, Fleck, and Rodriguez (1992) examined children's recall and recognition for material from a video about a doctor's visit. The characters in the video showed either positive, negative or neutral affect. After a 30-minute delay, children completed a free recall task in which they acted out the scene using dolls. This was followed by specific questions designed to elicit verbal free recall and a recognition task for specific information. Five- and 6-year-olds showed more errors in the negatively valenced condition than in the neutral or positive conditions, while older children did not, suggesting age-related change in the effects of emotion on memory. Davidson, Luo, and Burden (2001) examined memory in 7-, 9- and 11-year-old children. Children were presented with stories about either high or low emotion events (e.g., a child's parents becoming angry with her or a child doing her homework). In stories that were shorter in length, there were no age-related differences in memory for the emotional behaviors, but older children did perform better than younger children on memory for non-emotional behaviors. In longer stories, older children recalled more emotional information than younger children. In both short and long stories, all children recalled more emotional than non-emotional behaviors. Similarly, Davidson (2006) examined 6-, 8- and 10-year-old children's memories for stories depicting happiness, anger, embarrassment, envy, guilt and pride. Memory for emotion behaviors was better than for non-emotion behaviors, and older children showed better memory than younger children.

Other laboratory-based studies of emotion memory in older children and adolescents focus on emotion memory in cases of psychopathology such as PTSD, anxiety, and depression. The control groups in these studies provide some of what is known about emotion memory in typically developing children. As specific clinical questions are beyond the scope of the current study, this section primarily focuses on on the findings from the control groups from these studies. Moradi et al. (2000) examined memory in older children and adolescents aged 9 to 17 years with and without PTSD. Their task involved both recall and recognition memory for neutral, positive and negative emotional words. All children recalled more neutral than emotional words, and the control children recalled more positive and neutral words than did the clinical sample. In the recognition task, enhanced memory was found for neutral relative to emotional words, and memory was better for positive than negative words for all participants. In the recall task, children with PTSD recalled fewer words than did controls. Daleiden (1998) presented a sample of high-anxiety and low-anxiety middle school children with positive, negative and neutral words. Memory for the words was then tested using a word fragment completion task to test perceptual-procedural memory, a graphemic cue task to test for declarative-procedural memory, a semantic cue task to measure conceptual-declarative memory, and a general knowledge task to measure conceptual-procedural memory. Non-anxious children showed better memory for both positive and negative words (relative to neutral words) in the word completion task, while anxious children showed a bias towards recalling more negative information on the conceptual tasks. Bishop et al. (2004) studied memory for emotional stories in 5- to 11-year-old children rated high and low on depressive symptoms. Children were grouped into 3 age groups: 5 – 7.5, 7.5-9.5 and 9 years 8 months to 11 years. The children rated low on depression (i.e., the group who could perhaps be considered the more typically-developing sample) recalled the positive and negative material from the stories equally well, and showed better recall for the emotional material than for the neutral, while children rated high on depression recalled more negative than positive or neutral material. Children in the oldest age group performed significantly better than did children in the youngest group, with the middle age group showing performance intermediate between that of the youngest and oldest children.

While the above cases are drawn from research designed to address questions about psychopathology, Jambaque, Pinibiaux, Dubouch, Fohlen, Bulteau, and Delalande (2009) examined memory for emotional and neutral words in 11- to 15-year-olds with and without temporal lobe epilepsy, a condition which is of interest because it affects brain structures known to be involved in emotion memory in adults. Participants were tested on recall for a story containing both neutral and emotional segments as well as on recall of neutral and emotional word lists. For the control group, memory was enhanced for the emotional portions of the story at both immediate and delayed tests. Memory enhancement was also seen for emotional words, and this effect was stronger for negatively than for positively-valenced words. Children with temporal lobe epilepsy did not show this memory enhancement for emotional material. No analyses of age-related changes in memory were reported.

Thus, there is some laboratory-based work that has examined emotional memory in children. However, it remains sparse. A literature search using both Google scholar and PsycInfo with the terms "children" "emotion" and "memory" and "emotional memory" "child" discovered no work that is comparable to that which has been done in adults in terms of examining the effects of specific aspects of emotion (i.e., valence and arousal) on specific forms of memory (i.e., recollection and familiarity), such as that described below in the section on Recollection and Emotion Memory in Adults.

The following sections provide background on recollection and familiarity, which are believed to underlie memory for complex events, how these forms of memory are involved in emotional memory in adults and examples of how they have been studied in children. The information in these sections provides the basis for the current developmental study.

Dual Process Models of Memory

According to dual-process models of memory, which are prevalent (but not universal, see Wixted 2007), two forms of memory, termed processes, are involved in recognizing previously-encountered people or items. Familiarity is a general sense of having seen something before, without recalling contextual details surrounding when or where the item was encountered. Recollection is memory for both the item and the contextual details (Yonelinas, 2002) and is sometimes referred to as source memory (e.g., Glisky, Polster & Routhieaux, 1995). An example may be helpful in understanding how these processes are involved in everyday memory. Imagine that you encounter a person and have the feeling that you have seen them before, but are unable to remember how you know them. This awkward situation involves familiarity-based recognition. If you were to not only recognize the person but also remember their name and that you met them at a conference where they were giving a presentation on memory, then recollection would be involved as well.

Recollection and familiarity can be dissociated at both the behavioral and neural levels. The goals of this section are to introduce the processes believed to subserve episodic memory and to show how they have been dissociated using various research methods. Before doing so, it is useful to discuss some of the terminology used in memory studies. The to-be-remembered item (as opposed to the context) may be referred to as either the "target" or the "item". When novel items are used in paradigms requiring a differentiation to be made between studied and unstudied (or "old" and "new") items, these novel items may be termed "distracters." Features surrounding the items are referred to as "context" or "source". Correct identification of an item as old may be referred to as a "hit", and correct identification of the source as a "source hit".

Behaviorally, recollection and familiarity have been studied in a variety of ways, including exclusion paradigms, remember-know paradigms, and source memory paradigms. In an exclusion paradigm (Jacoby, 1991), items are presented in two different contexts. At retrieval, participants are instructed to respond to targets from one (but not the other) of the two contexts, and to ignore novel distracter items not seen in the first part of the study. Remember-know paradigms (Tulving, 1985) ask participants to indicate whether they "remember" encountering the target (i.e., have the subjective experience of recollecting the episode in which they encoded the item) or "know" that they have seen it before (i.e., have a feeling of familiarity without recollection). In source memory paradigms, items may be presented in different colors (e.g., Cycowicz, Friedman, Snodgrass, & Duff, 2001), or in different modalities (e.g., Kelley, Jacoby, & Hollingshead, 1989) or in different voices (e.g., Glisky et al., 1995; Senkfor & Van Petten, 1998). At recall, participants are asked whether items are old or new, and for items endorsed as old, they are asked to indicate which context ("source") was associated with the item at encoding. Successful performance in item recognition may be based upon familiarity or recollection, whereas successful performance on a source task requires recollection (Yonelinas, 2002).

In addition to being dissociable on the basis of behavior, there is evidence that recollection and familiarity differ in terms of both neural substrates and developmental trajectories. In studies examining the neural substrates of memory, functional neuroimaging and electrophysiological methods suggest that familiarity and recollection are distinct forms of memory as they engage partially overlapping but distinct neural circuitry (for a review, see Friedman & Johnson, 2000). As the current study focuses exclusively on behavior, the specifics of this are beyond the scope of this paper, but it is worth noting that the evidence from neuroscience strongly supports dual-process models of memory. In terms of development, recollection shows a different, more prolonged developmental trajectory, (e.g., Ghetti & Angelini, 2008). This will be discussed in more detail in a later section.

Recollection and Emotion Memory in Adults

Dual-process models have been applied to the study of emotion memory in adults in order to understand more precisely how emotion enhances memory. These studies have included both those in which the target item is emotional and those in which a neutral target is paired with an emotional context.

In studies that have used target items that are themselves emotional in nature, findings suggest that recollection, rather than familiarity, underlies the enhancing effects of emotion. Some studies have focused on the effects of valence. For example, Dolcos, LaBar, and Cabeza (2005) used a remember-know procedure to examine the effects of emotional valence on memory, and found that after a one-year delay, memory for emotional material was better than for neutral material, particularly for recollected items. In a remember-know study using neutral and emotional faces, Johansson, Mecklinger, and Treese (2004) found that negative faces engaged recollection to a greater extent than did neutral or positive faces, both as indexed by the number of “remember” responses given in a remember-know task and by electrophysiological measures. Thus, valence was shown to significantly improve recollection.

Other studies have focused on the effects of both dimensions of emotion. In a series of experiments, Kensinger and Corkin (2003b) examined the effects of valence and arousal on emotion memory, using both a remember-know procedure and a source memory paradigm. They found that negative words were given a “remember” response more frequently than neutral words, suggesting that the valence of the words had an enhancing effect on recollection. In addition, in the source memory paradigm, in which words were presented in either red or blue font, and memory was tested for both the word and its color, they found enhanced recollection for negative compared to neutral material. Overall, they found that recollection was enhanced by both valence and arousal, but that arousal had a greater effect. Doerkson and Shimamura (2001) also concluded that arousal enhanced memory, by using a source memory paradigm with emotional and non-emotional words that were presented in either a blue or a yellow frame. While this study initially examined only valence, the valenced words used were rated as more arousing than the neutral words. Since similar effects were seen for both positive and negative valence, the authors concluded that arousal was a more likely explanation for their effects.

The above studies demonstrate that recollection is enhanced for emotional material. However, a serious confound in these studies is that the items used were themselves emotional in nature, making separation of the effects of emotion and memory problematic. Other studies have attempted to avoid this confound by manipulating the emotional content of the context rather than the emotional content of the item (e.g., Erk, Martin, & Walter, 2005; Smith, Dolan, & Rugg, 2004). This approach allows conclusions about how emotion affects memory and, furthermore, how emotional state drives this effect.

On the whole, these studies in adults suggest that enhanced memory for emotional material relative to neutral material is due to the effects of emotion on recollection. They also suggest that emotion may engage additional neural mechanisms not normally involved in emotionally neutral memory. For example, Smith et al. (2004) employed both behavior and event-related potentials (ERPs) to examine item and source memory for neutral pictures, which were presented in either an emotionally valenced or neutral context. At encoding, participants first viewed a background image and were asked to rate it for valence. After this rating, the background was presented again, this time with a neutral target item superimposed on it. Participants were instructed to imagine a connection between the item and the background. At retrieval, both item memory and source memory were examined, using an item-only task in one experiment, and a source memory task in a second experiment. In the source task, participants were asked to report the valence of the background picture each item was paired with at encoding. It was found that both item and source memory were enhanced for items encoded in an emotionally valenced context.

Overall, the literature suggests that emotionally valenced and emotionally arousing material enhance recollection memory in adults. Since recollection shows a prolonged trajectory over development, whether and how emotion affects children's memory is of particular interest. The following section provides background on the study of recollection in children.

Recollection and Development

As mentioned above, recollection and familiarity show different developmental trajectories, with recollection developing more slowly than familiarity through childhood and adolescence. The purpose of this section is to provide background on the ways in which these developmental changes have been studied and what is known about recollection in childhood, as well as to suggest how these methodologies can be applied to the study of emotion memory in children.

The development of recollection has been studied in school-aged children using exclusion paradigms. For example, Czernochowski, Mecklinger, Johansson, and Brinkmann (2005) examined recollection and familiarity in 6- 8-year-old children, 10-12-year-olds and adults. Stimuli were presented at encoding as either photographs or spoken words. During the test phase, stimuli were presented as line drawings. In one condition, participants completed an old-new task in which they indicated whether or not an item had been previously studied. In a second condition, an exclusion paradigm was employed in which participants were instructed to respond only to targets that had been encountered in one of the encoding source contexts. Adults showed better performance than children in both tasks, with the increase in source memory performance statistically independent of the increase in item memory performance. Similarly, Cycowicz, Freidman, and Duff (2003) used an exclusion paradigm in 10-year-olds, adolescents, and adults. At encoding, pictures were presented in one of two colors. At recall participants were asked to either make an old-new judgment or to endorse targets seen in only one of the source colors. Consistent with the evidence regarding the prolonged developmental trajectory of recollection, the older groups showed an advantage in the source judgment. In both of these studies, ERPs were also collected. As the focus of this paper is behavior, and not electrophysiology, the details of the ERP findings are not discussed here, but it is worth noting that they are consistent with the prolonged development of recollection.

Other studies have looked at a broad range of ages encompassing childhood through late adolescence using remember-know and source memory paradigms. Using a remember-know procedure with children and adolescents aged 8 to 19 years, Billingsley, Smith, and McAndrews (2002) found that overall memory performance, and correct "remember" (but not "know") responses increased with age, with children aged 11-13, 14-16, and 17-19 performing better than children aged 8-10. No age-related differences were seen for "know" responses, indicating that recollection, but not familiarity, showed prolonged development over this age range. Similarly, in a study of children and adolescents aged 6, 8, 10, 14 years and 18 years, Ghetti and Angelini (2008) showed that recollection undergoes protracted development into adolescence. They used a source memory task in which participants were presented with line drawings in either red or green ink. At retrieval, they were shown the pictures in black ink and asked to make an old-new judgment. For items endorsed as old, participants were asked to indicate the color in which the item was originally presented. Based upon participants' behavior as well as mathematical models of familiarity and recollection (i.e., receiver operating characteristics or ROCs), the authors found that recollection, undergoes prolonged development in this age range, while familiarity remains stable.

The above studies provide examples of how different types of memory paradigms can be applied to the study of recollection in children, and demonstrate that appropriate research tools are available to examine recollection in children. In addition, these studies demonstrate the prolonged development of recollection.

Research Questions

Emotion has been shown to enhance memory in children and adults. In adults, this effect is due to enhanced recollection, a form of memory that shows a prolonged developmental trajectory. Because of this prolonged development, it is of interest to examine the effects of emotion on item and source memory in childhood, as these effects and the specific forms of memory involved may change in non-obvious ways over development.

The current study was designed to examine how the emotional nature of the context in which an item is encountered affects memory. Within this broad topic, there are many possible lines of research, but as an initial investigation at the group level, these are beyond the scope of the current study. For example, the experiences of long-term versus acute emotional arousal have been shown to affect memory differentially (Carver & Cluver, 2009). The current study only addressed the effects of acute emotional arousal on memory. In addition, it is quite possible (even probable) that there are individual differences in how emotional stimuli affect memory (for a review, see Alexander & O'Hara, 2009). However, the effects of such differences are not addressed in this study.

Based on the methods of Smith et al. (2004), this study presented items in an emotional context at the time of encoding, and tested retrieval in a neutral context. While the effects of emotion on memory can be studied either at encoding (e.g., Dolcos & Cabeza, 2002) or at retrieval, as in the studies described above, the current study will focused on retrieval as it is better suited to behavioral measures.

The present study aimed to examine whether emotion facilitates children's memory and if so, whether this facilitation is due to the effects of emotion on recollection. As emotion can be conceptualized in terms of both valence and arousal (Bradley et al., 1992; Mehrabian & Russell, 1974; Russell, 1980; Kensinger & Corkin, 2003a), this study separately examined the effects of valence and arousal on item and source memory. This represents a unique contribution to the study of memory and emotion in childhood, as no such work has been previously conducted.

It was hypothesized that there would be an enhancement in memory for those items presented in an emotional context, as has been found in previous studies with children (Bishop et al., 2004; Davidson et al., 2001; Daleiden, 1998; Jambaque et al., 2009) and adults (Bradley et al., 1992; Bradley & Lang, 2000). In addition, based upon previous research with adults (Doerkson & Shimamura, 2001; Dolcos et al., 2005; Johansson et al., 2004; Kensinger & Corkin, 2003b), it was hypothesized that recollection would specifically be enhanced.

Specifically, the hypotheses were:

1. Item memory would be enhanced for items encoded in a valenced context.
2. Source memory (i.e., recollection) would be enhanced for items encoded in a valenced context.
3. Item memory would be enhanced for items encoded in an arousing context.
4. Source memory would be enhanced for items encoded in an arousing context.

Chapter 2: Methods

The study comprised two stages, encoding and retrieval, which both occurred during a single 90-minute visit to the Neurocognitive Development Lab. All procedures were approved by the University of Maryland's Institutional Review Board (see Appendix 1) prior to starting data collection. In this study, an emotional background was paired with a neutral target item. By using neutral targets paired with emotional backgrounds, it is possible to parse out the contribution of emotion as separate from the target item, allowing the isolation of the impact of emotion on memory without memory for item and memory for emotion being confounded. Rather than examining memory for emotional content of the target items, this design allows for the examination of the effects of emotional state on memory (Erk et al., 2005).

Participants

Participants were recruited from a database maintained by the University of Maryland Infant and Child Studies program. A total of 47 children participated in the study. One child was excluded due to failure to follow instructions. Three children were excluded due to equipment failure. One child was excluded due to a diagnosis of ADHD, leaving a final sample of 42 children (23 girls, 19 boys, M_{age} = 8.3 years, age range: 7-9 years). Of these, 29 children were Caucasian, 9 were African American, 2 were Asian, 1 was Pacific Islander and African American and 1 chose not disclose their racial and ethnic background.

Parents provided informed consent for their children, and children provided written assent. Children received a small toy for their participation.

Stimuli

Backgrounds were a subset of pictures drawn from the International Affective Picture System (IAPS, Lang, Bradley, & Cuthbert, 2008) judged by the author and several parents to be appropriate for children. Target items included pictures of plants and common inanimate objects drawn from the Snodgrass pictures (Snodgrass & Vanderwart, 1980).   A total of 60 item-background parings were presented. Backgrounds were chosen to include a range of valence and arousal, based upon ratings from a separate group of 11 children, with the goal of including equal numbers (i.e., 10 each for the emotional pictures) of negative valence-low arousal, negative valence-high arousal, positive valence-low arousal, positive valence-high arousal pictures as well as 20 neutral pictures (see Figure 1 for examples of stimuli similar to those used in the study). All stimuli were presented on a computer screen using E-Prime 2.0 stimulus presentation software (PST, Pittsburgh, PA).

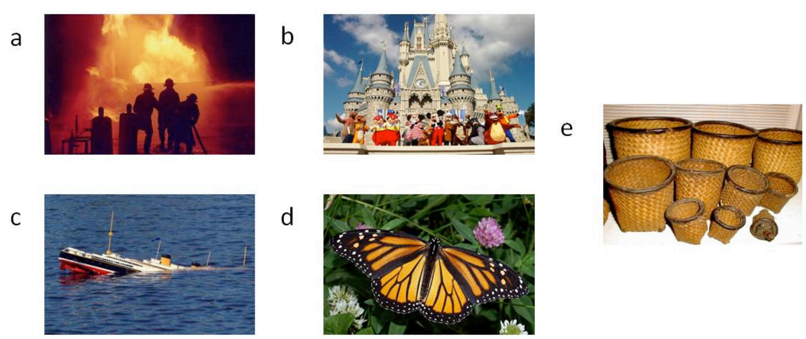


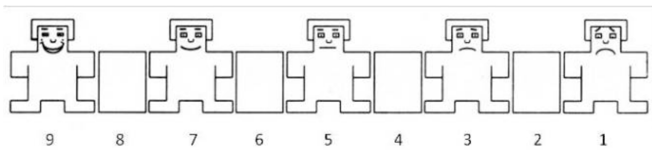
Figure 1. Examples of different types of background stimuli: a) negative valence-high arousal, b) positive valence-high arousal, c) negative valence-low arousal, d) positive valence-low arousal, and e) neutral.

Procedure

Encoding. During encoding, children viewed a total of 60 background-item pairings. The background image was presented first for 1 second. Following this presentation, the child was presented with the Self-Assessment Manikin (SAM, Lang, 1980, see Figure 2), used in the development of the IAPS, which includes a 9-point scale for valence (1= *most negative valence*, 9 = *most positive valence*) and a separate 9-point scale for arousal (1= *lowest arousal*, 9 = *highest arousal*). Children were provided with instructions based upon those given to child participants by Lang et al. (2008) during development of the IAPS (see Appendix 2 for full script). After ratings were provided, the background image was presented again, this time with the target item superimposed on it, for 3 seconds. Targets were presented in a white box in order to distinguish them clearly from the background. Participants were instructed to imagine a connection between the item and the background and to report it out loud to the experimenter, in order to promote encoding of the background-item pairing. A practice block was completed prior to experimental trials in order to ensure that children understood the instructions. The encoding procedure was then repeated for all 60 experimental stimulus pairings. The encoding portion lasted between 20 and 40 minutes, with variation in the length of time due to differences in the length of time that children took to provide valence and arousal ratings and differences in the length of children's descriptions of the connections between background and target.

Children were given a 5-minute break between encoding and retrieval during which they played with age-appropriate toys in the lab. It has been found that while a longer delay strengthens the effects of emotion on memory, a 5-minute delay is sufficient to produce this effect in adults (Sharot, Verfaellie, & Yonelinas, 2007), and due to practical scheduling considerations, this short delay was chosen.

a



b

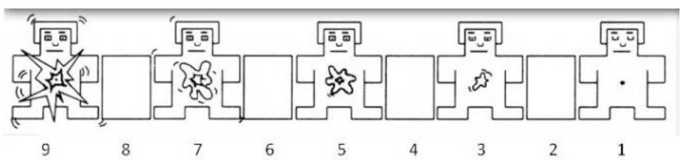


Figure 2. Self-Assessment Manikin (SAM, Lang, 1980), used to obtain a) valence ratings and b) arousal ratings.

Retrieval. At retrieval, children viewed the original 60 target items, as well as 20 distracters, also drawn from the Snodgrass images (Snodgrass & Vanderwart, 1980), all on a white background. Stimuli were presented one at a time in random order and were on the screen for 1500 ms. For each picture, the child was asked to indicate whether the item was old or new. For those items endorsed as old, children were asked to think of the source picture with which the item was paired during encoding. They were then asked to verbally report both what the background picture had been of and the SAM valence rating that they had given at encoding.

See Figure 3 for an overview of the procedures used.

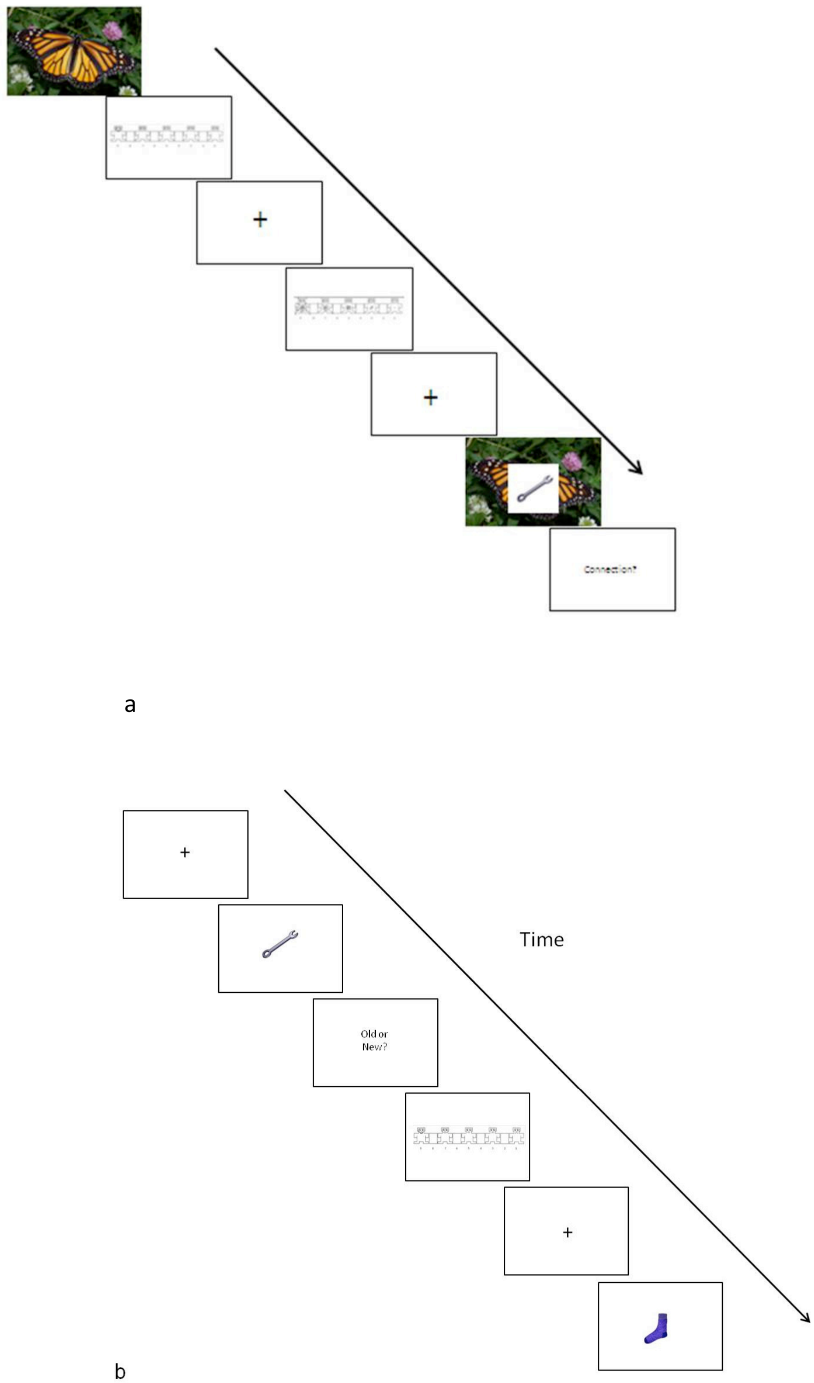


Figure 3. Overview of procedures for a) encoding and b) retrieval.

Data analysis

Valence and arousal conditions were based upon each child's judgment of the background picture the target was paired with at encoding. All targets were neutral images, and will hereafter be referred to by the valence and arousal ratings that were given to the background with which they were paired at encoding. Thus, if a target image of a tree was paired with a picture the child judged to be positive at encoding, it is now termed "positive", even though the target itself was not valenced. Each picture was assigned to a valence category based upon the individual child's response to the picture during encoding. Pictures rated 1-3 on the valence SAM were scored as negative, pictures rated 4-6 were scored as neutral, and pictures rated 7-9 were scored as positive. Because this resulted in different numbers of pictures in each category for different children, proportions were used as the dependent variables. The mean number and range of pictures in each category is reported below. For item analyses, proportion item correct was calculated for each valence category as the number of items in that valence category correctly identified as old divided by the number of items rated as having that valence. For source analyses, proportion source correct was calculated for each category as number of items with source correct divided by the number of items correctly identified as old in that valence category (see additional information regarding source analyses below). Arousal ratings were not considered in these analyses as these analyses address the question of whether there is an impact of valence on item and/or source memory.

Arousal was categorized as either high or low, based upon the individual child's response to each picture. Ratings of 1-4 were considered to be low arousal and 5-9 to be high arousal.[1] As with valence, proportions were used as the dependent variables.

For all source analyses, successful source performance was assessed using two different criteria. As in the adult literature (e.g., Smith et al., 2004), the first criterion was whether the source valence (positive, negative, or neutral) given at retrieval was the same as that given at encoding. The second criterion was whether the description of the source picture given at retrieval was correct. [2] When the first criterion was met it is referred to as “source hit-valence rating”, and when the second was met it is referred to as “source hit-description”. The analyses in which memory for encoding valence was used as an index of source were included in order to be consistent with the adult literature (e.g., Smith et al., 2004). Background description was included because it was unclear whether memory for the valence rating would prove to be an appropriate index of source memory in children this age, whereas a correct description of the background can more confidently be considered correct source memory. Gender was included as a between-subjects factor in all analyses as sex differences have been reported in studies of emotion memory in adults, both in terms of brain activation (see Hamann and Canli, 2004 for a review) and in terms of behavior, with women showing faster recall for emotional memories, as well as reporting these memories as richer and more intense than do men (Hamann, 2005).

Chapter 3: Results

Preliminary analyses of stimulus ratings and overall memory performance are presented first. This is followed by the primary analyses examining the effects of valence and arousal on item and source memory. Finally, analyses examining the effects of valance and arousal on item and source memory were reconducted with age included as a covariate.

Preliminary Analyses

The mean number of items rated positive was 20.98 (SD = 7.22, range: 4 to 39). The mean number of items rated negative was 15.26 (SD = 7.07, range: 0 to 25). The mean number of items rated neutral was 23.74 (SD = 9.18, range: 9 to 48). The number of items in each valence category was significantly different, $F(2, 125) = 12.63$, $p < .001$, with more pictures rated positive or neutral than negative.

The mean valence ratings for each category were: positive 8.25 (SD = .88), negative 1.67 (SD = .85) and neutral 4.97 (SD = .57). An ANOVA showed a significant effect of valence condition, $F(2, 2516) = 13927.85$, $p < .001$, and follow up t-tests showed that ratings for all categories were significantly different from each other, p's < .001.

The average number of items rated low arousal was 25.62 (SD = 12.65, range: 3 to 58). The average number of items rated high arousal was 34.33 (SD = 12.59, range: 2 to 57). The number of items in each arousal category was significantly different, $F(1, 82) = 10.01$, $p = .002$.

The mean arousal rating for the low arousal condition was 2.00 (*SD* = 1.13), and the mean rating for the high arousal condition was 7.26 (*SD* = 1.62). Ratings for the two conditions were significantly different, $F(1, 2517) = 8299.82$, $p < .001$. The overall proportion item correct (defined as the number of items correctly identified as old divided by 60) was .77 (*SD* = .13, range: .4 to .98). The overall proportion source hit-valence (defined as the number valence correct divided by the number correctly identified as old) was .69 (*SD* = .15, range: .39 to .96). The overall proportion source hit-description (defined as number description correct divided by the number correctly identified as old) was .70 (*SD* = .12, range: .43 to .94).

Primary Analyses

Valence. One child did not rate any items as negative. Thus, this child was excluded from the following valence analyses. No main effects of gender or interactions with gender were found in any of the following analyses.

A 2 x 3 (Gender [female, male] x Valence [positive, negative, neutral]) repeated-measures ANOVA was conducted for proportion of items correctly identified as old. No significant effect of valence on item memory was found, $F(2, 78) = 2.28$, $p = .11$. As shown in Figure 4, mean proportion item correct for the positive condition was .80 (*SD* = .13), for the negative condition, the mean was .77 (*SD* = .16) and for the neutral condition, the mean was .75 (*SD* = .18).

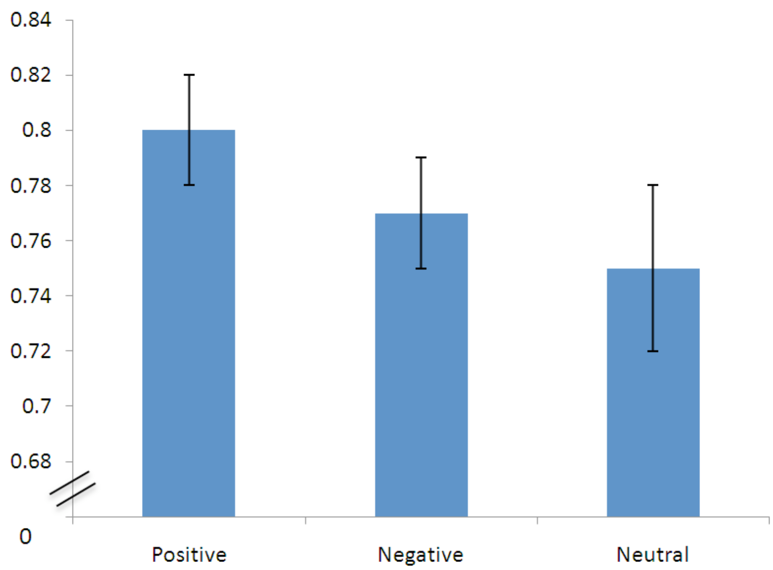


Figure 4. Item memory for positive, negative and neutral valence.

Separate 2 x 3 (Gender [female, male] x Valence [positive, negative, neutral]) repeated-measures ANOVAs were conducted for each of the source measures. No significant effect of valence was found in either of these analyses (see Table 1 for a summary of the findings).

Table 1
Valence Results-Original ANOVA

Measure	*F* (2, 78)	*p*	Positive	Negative	Neutral
Proportion source hits-valence	1.31	.28	.61 (*SD* = .20)	.60 (*SD* = .28)	.68 (*SD* = .27)
Proportion source hits-description	2.16	.12	.73 (*SD* = .15)	.73 (*SD* = .20)	.68 (*SD* = .17)

Arousal. A 2 x 2 (Gender [female, male] x Arousal [low, high]) repeated-measures ANOVA was conducted for proportion of items correctly identified as old. No significant effect of arousal was found on item memory, *F* (1 , 40) = .007, *p* = .94. As shown in Figure 5, the mean proportion correct for items paired with a low arousal background at encoding was .74 (*SD* = .18) and the mean for items paired with a high arousal background was .74 (*SD* = .18).

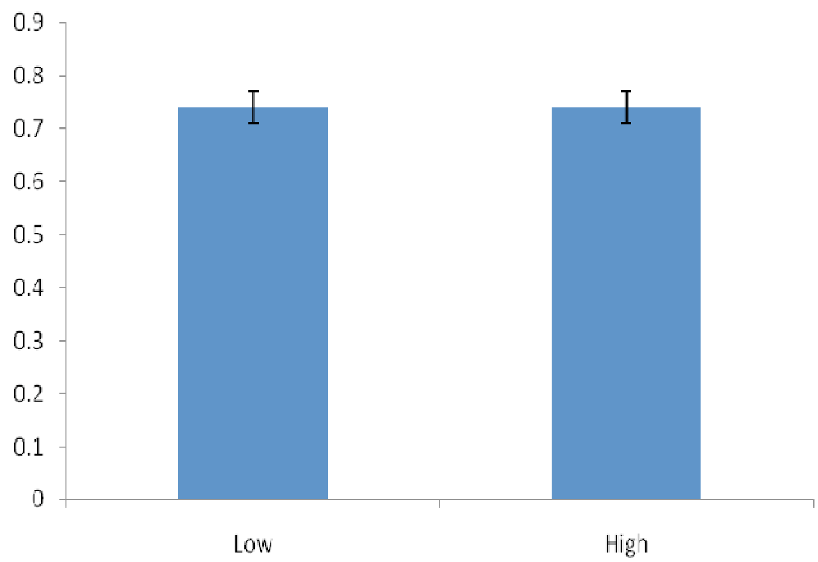


Figure 5. Item memory for low and high arousal.

Separate 2 x 2 (Gender [female, male] x Arousal [low, high]) repeated-measures ANOVAs were conducted for each of the source measures. One child was excluded from these analyses because they did not have any high arousal items correct. No significant effect of arousal was found in either of these analyses (see Table 2 for a summary of the findings).

Table 2
Arousal Results-Original ANOVA

Measure	*F* (1, 39)	*p*	Low Arousal	High Arousal
Proportion source hits-valence	.003	.96	.67 (*SD* = .24)	.67 (*SD* = .18)
Proportion source hits-description	.161	.69	.68 (*SD* = .21)	.68 (*SD* = .16)

Analyses with age included as a covariate

Although the initial analyses did not reveal significant effects, the pattern of the means in both the item and description analyses suggested a pattern consistent with an effect of valence on memory. Because age-related improvements in memory are often reported, correlations between age and overall memory (without regard to valence) were examined. A trend for a correlation was found between age and proportion item correct, $r = .29$, $p = .069$, and a significant correlation was found between age and proportion source hit-description, $r = .46$, $p = .002$, but not between age and proportion source hit-valence, $r = .13$, $p = .42$. Thus age may be a source of variance in memory performance even in this relatively restricted range, with older age associated with better memory performance. In order to statistically control for the effects of age, a second set of analyses was conducted with age as a covariate. These analyses were conducted for item memory and for source hit-description. Source hit-valence was not included in these analyses as no correlation with age was observed.

Valence with age as a covariate. A 2 x 3 (Gender [female, male] x Valence [positive, negative, neutral]) repeated-measures ANOVA with age as a covariate was conducted for proportion of items correctly identified as old. A significant main effect of valence was found, $F(2, 76) = 3.22$, $p = .045$. The mean proportion correct for the positive condition was .79 (*SD* = .13). The mean for the negative condition was .77 (*SD* = .16), and the mean for the neutral condition was .75 (*SD* = .17). Pairwise comparisons indicated that positive was significantly different from neutral, $p = .04$. Negative did not differ from positive or neutral, *p*'s > .94.

A 2 x 3 (Gender [female, male] x Valence [positive, negative, neutral]) repeated-measures ANOVA with age as a covariate was conducted for proportion source hit-description. As in the original analysis, no significant effect of valence was found, $F(2, 76) = .92$, $p = .403$. mean proportion description correct for the positive condition was .72 (*SD* = .15). The mean for the negative condition was .73 (*SD* = .20). The mean for the neutral condition was .67 (*SD* = .16).

Arousal with age as a covariate. A 2 x 2 (Gender [female, male] x Arousal [low, high]) repeated-measures ANOVA with age as a covariate was conducted for proportion of items were correctly identified as old. As in the original analysis, no significant effect of arousal was found, $F(1, 39) = 2.67$, $p = .111$. The mean proportion correct for items paired with a low arousal background at encoding was .74 (*SD* = .17). The mean for items paired with a high arousal background was .74 (*SD* = .18).

A 2 x 2 (Gender [female, male] x Arousal [low, high]) repeated-measures ANOVA with age as a covariate was conducted for proportion source hit-description. There was a significant gender by arousal interaction, $F(1, 38) = 6.70$, $p = .014$. This interaction was followed up with separate repeated-measures ANOVAs with age as a covariate for girls and boys. Neither gender showed a significant effect of arousal (p's > .167), but the pattern of means suggested that girls had better source memory for high than for low arousal, while the opposite was true for boys (Figure 6).

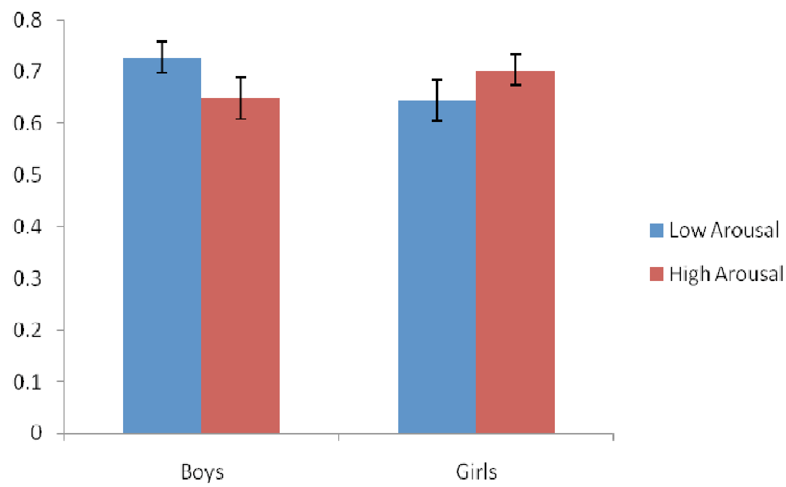


Figure 6. Source memory for arousal by number with age as a covariate plotted for boys and girls separately.

Chapter 4: Discussion

Overall memory performance was quite good, both on item and source tasks. Consistent with previous findings of age-related improvements in overall memory (e.g. Chen et al., 2000; Peterson, 1999; Peterson & Whalen, 2001; Davidson, 2006; Davidson et al., 2001; Bishop et al., 2004), this study found that older children showed better memory overall than did younger children, even within the narrow age range included in this study. When age was not included as a covariate, no significant effects were found for valence or arousal on either item or source hits. For valence, the means for item and source hits-description were in the expected direction, with better memory for positive and negative than for neutral, but the pattern of means for source hits-valence was opposite, with better memory for neutral. The means for high and low arousal were nearly identical in all conditions.

The difference in the pattern of means between source hits-valence and source hits-description in the valence analyses raises questions as to which measure of source memory is more valid. Source hits-valence showed a memory advantage for neutral relative to valenced material, while source hits-description showed the hypothesized pattern, with source memory enhanced for the valenced conditions. The source hits-valence condition was included because it is the measure that has previously been used with adults (e.g., Smith et al., 2004). However, there are several reasons to think that it is not the best measure. The findings from this measure are inconsistent with nearly all of the studies of emotion memory in adults and children that have been cited in this paper (with the exception of Moradi et al., 2001). Also, unlike the other measures, there is no correlation between source hits-valence and age. This lack of correlation does not fit with the general finding of age-related improvement in memory (e.g., Chen et al., 2000; Peterson, 1999; Peterson & Whalen, 2001; Davidson, 2006; Davidson et al., 2001; Bishop et al., 2004), which suggests that this measure does not behave like other established measures of memory. Finally, source hits-description may be the better measure because we can be more confident that the child is in fact remembering the background as they were asked to recall what it was, and so chance performance is very small, whereas in source hits-valence, chance is 33% and we cannot be entirely sure that the child is not simply guessing.

The reason for the difference in results between the two measures bears consideration. There is some uncertainty as to what exactly is being measured by source hits-valence, as children must remember in order to provide a description of the source, and in giving the valence rating, they may be consulting their current emotional reaction to the stimulus as retrieved rather than reporting their initial reaction at encoding. Thus it is unclear whether they were reporting the emotional reaction that they had at encoding or their current emotional reaction to the memory of the first presentation. In addition, because the source hits-valence condition looks only at valence responses, without regard to whether or not the source description was correct, children's answers may reflect a combination of remembering and guessing. Lastly, the pattern observed for source hits-valence may also be due to the way in which the questions were posed. At retrieval, children were asked to think of the background picture and to report both the picture and the SAM rating. For children who did not answer immediately, or who needed prompting, the description was prompted first, and then the valence was asked about. This may have resulted in the description receiving more emphasis in children's minds, leading them to focus more carefully when giving these answers. Future studies in which children are asked only about valence, and not about the description, as well as studies in which adults and children are asked about both description and valence, may help to determine if this was the case.

In the valence analyses, for item and source hits-description, the fact that the hypothesized pattern was present in the means, but the difference was not significant at the group level, raised the possibility that this effect was present in some, but not all, children in this age group, or that it was present, but in an emerging and not-yet robust form. As age was correlated with overall performance on both of these measures, this question was addressed by a second set of analyses that included age as a covariate. In these analyses, there was a significant effect of valence on item memory, with the mean proportion of positive remembered greater than the mean proportion of negative, which was greater than the mean proportion of neutral, but no significant effect on source memory, although the means suggested that source memory was better for positive and negative than for neutral. Thus, when age was taken into account, valence improved item memory.

In the arousal analyses in which age was included as a covariate, there was no effect of arousal on item memory, but for source memory there was an interaction with gender. Specifically, girls showed better source memory for high arousal and boys showed better source memory for low arousal, although in neither case did this reach statistical significance. Nonetheless, it appears that the effect of arousal on source memory differs by gender.

The findings indicate that there are age-related change in memory abilities within this age group. When these changes are statistically controlled, a pattern emerges in which item memory is significantly enhanced by emotion, consistent with the adult literature (e.g., Bradley et al., 1992; Bradley & Lang, 2000; Smith et al., 2004). This is also consistent with other studies of children (e.g., Davidson, 2006; Davidson et al., 2001; the non-anxious group in Daleiden, 1998; the non-depressed group in Bishop et al., 2004; the control group in Jambaque et al., 2009), in which memory was better for emotional than for non-emotional material.

The pattern of means for source hits-description showed better source memory for positive and negative than for neutral, but this did not reach statistical significance, even when age was covaried, so although valence enhanced item memory, it did not significantly enhance source memory, in contrast to findings with adults (e.g., Dolcos et al., 2005; Johansson et al., 2004). The reasons for this merit further scrutiny. As mentioned previously, the ways in which emotion affects memory may vary across development. This appears to be the case for valence, as valence improves both item and source memory in adults, but only significantly improved item memory in the children in the present study. It may be that valence is actually enhancing recollection in children, but because recollection is not yet fully developed, item memory, supported by both familiarity and recollection, is enhanced, but source memory, relying on recollection alone, is not. Alternatively, emotional valence may only impact familiarity (but not recollection) in children this age. These possibilities could be disambiguated with ERP studies, as valence-based differences in ERP components associated with recollection would be evidence that valence is impacting recollection, just not in a form reliably detectable in behavior.

Arousal did not significantly affect item or source memory in the present study, which is inconsistent with the findings in the adult literature, although there was a significant interaction with gender for source memory. Girls showed a pattern similar to that seen in adults (with better source memory for items encoded in a highly arousing context, e.g., Bradley et al., 1992; Bradley & Lang, 2000; Doerkson & Shimamura, 2001; Dolcos et al., 2004; Kensinger & Corkin, 2003b), while boys showed the opposite pattern. The lack of overall significant findings may be due to the fact that arousal had opposite effects on girls and boys, so that at the level of the overall group, effects were not significant, and when the sample was split by gender, there was not sufficient power to detect an effect.

The gender differences observed in this study may be due to differences in brain development, general recollection ability, or factors related to socialization. Differences have been found between girls and boys in areas of the brain associated with emotion memory. Specifically, boys and girls show differences in patterns of hippocampal development (eg., Gogtay et al., 2006; Pfluger et al., 1999; Giedd et al., 1996), as well as in the structural and functional development of the amygdala (eg. Giedd et al., 1996; Thomas et al., 2001). Behaviorally, girls have been found to show more mature recollection for non-emotional material than boys (Ghetti & Angelini, 2008). Social factors may also play a role. For example, Fivush, Brotman, Buckner and Goodman (2000) found that among 4-year-olds, girls talked more about emotions, and in a longitudinal study of parent-child conversations about past emotional events, it was found that parents talked to their daughters more frequently and about a broader range of emotions than they did with their sons (Adams, Keubli, Boyle & Fivush, 1995). These differences may affect how children think about and remember emotion and how emotion affects children's cognition (Davidson, 2006), and possibly memory. If this is the case, the gender differences observed in this sample might not be seen in cultures where gender-based parent-child interaction does not follow this pattern.

In summary, when age is controlled statistically, it appears that both valence and arousal affect memory, but in different ways, with valence enhancing item memory and arousal enhancing memory in girls, but impairing memory in boys. These findings suggest that there may be different developmental trajectories for the effects of valence and arousal on memory. One possible explanation for this difference between valence and arousal lies in differences in the development of their neural substrates (i.e., the PFC and amygdala), which have been found to show different maturational patterns (see Casey, Giedd & Thomas, 2000 for a review).

Consistent with the adult literature, and with the hypothesis that item memory would be enhanced by encoding in an emotionally valenced context, item memory was better for items encoded in a positive or negative context than those encoded in a neutral context. However, contrary to the hypothesis that source memory would be enhanced for items encoded in a valenced context, no significant effect of valence was found. Thus, the impact of valence on memory is not identical in 8-year-olds and in adults.

The results of this study are inconsistent with the hypothesis that item memory is improved for items encoded in a highly arousing context. However, they do suggest that arousal affects source memory in this age group, and that these effects differ by gender, with girls showing enhanced source memory for the high arousal condition (as hypothesized and consistent with the pattern seen in adults), while boys show the opposite pattern (inconsistent with the pattern seen in adults), although no statistically significant main effect of arousal was observed for either gender, perhaps due to a lack of power.

Chapter 5: Future Directions

The present study was the first that has attempted to adapt a source memory paradigm to study the effects of valence and arousal on recollection in children. As this is the case, it will be important to replicate these findings in the future. In addition, there are many ways in which this research can be expanded upon.

Methodologically, future studies or replications may incorporate improvements to the current study design. For example, it may be worthwhile to either statistically control for differences in the time each child spent on the encoding portion, or to impose a limit on how long children can take to provide valence and arousal ratings in order to remove this potential source of variability between children. Additionally, it would be of interest to record the encoding session for subsequent analysis, such as examination of differences in the types of connections that children make between background and target and whether these are related in a systematic way to memory performance. In terms of analyses, it would be illuminating to more directly examine the interaction of valence and arousal by considering them in the same analysis, rather than in two separate analyses as in the current study.

The use of ERPs and other electrophysiological or imaging techniques might also be applied to these questions as recollection and familiarity are associated with different patterns of neural activation (Friedman & Johnson, 2000). Given the trends that did not reach statistical significance in the current study and the problems of determining precisely what memory component was contributing to specific effects, ERPs and neuroimaging techniques potentially offer better sensitivity and the ability to distinguish the contributions of recollection from those of familiarity. For example, it is not clear whether the lack of significant effects of valence on source memory means that valence only affects familiarity in 8-year-olds. This question could be addressed using ERPs, as valence-based differences in ERP components associated with recollection would be evidence that valence is impacting recollection, just not in a behaviorally reliable form.

Future work may examine the development of emotion memory and the effects of emotion on specific forms of memory across multiple time points in development, ideally longitudinally from early childhood through adolescence. This work is of interest given the different developmental courses of the memory processes of familiarity and recollection, as well as the possibility that the effects of valence and arousal may show different developmental courses.

Future studies in which children are asked only about valence, and not about the description, as well as studies in which adults and children are asked about both description and valence, may help to shed light on the reasons behind the different findings for source memory when source was measured as valence versus when source was measured as description. In order to examine whether the gender differences observed in this sample are due to differences in how children are socialized to process emotional information, this study might be replicated in cultures where gender-based parent-child interaction does not follow this pattern.

Finally, it would be illuminating to examine individual differences in emotion memory based upon factors such as temperament, attachment quality, or even genetics, as all of these factors may be associated with differences in the processing of emotional information. Such work may have implications for specific clinical populations, in addition to serving to improve our understanding of the factors influencing the development of specific forms of memory.

Appendix 1

IRB Approval Letter

June 04, 2010

To: Investigator: Tracy Riggins

Co-Investigator(s): Not Applicable

Student Investigator: Meghan Elisabeth Graham

Department: BSOS - Psychology

From: Joseph M. Smith, MA, CIM

Manager

University of Maryland, College Park

Re: IRB Application Number: 10-0326 (PAS# 3108)

Project Title: "Neurobehavioral investigation of the effects of emotion on memory during development"

Approval Date: 06-03-2010

Expiration Date: 06-03-2011

Type of Application: New Application

Type of Research: Non-Exempt

Type of Review: Expedited

The University of Maryland, College Park Institutional Review Board (IRB) approved your IRB application. The research was approved in accordance with the University's IRB policies and procedures and 45 CFR 46, the Federal Policy for the Protection of Human Subjects. Please reference the above-cited IRB application number in any future communications with our office regarding this research.

Recruitment/Consent: For research requiring written informed consent, the IRB-approved and stamped informed consent document is enclosed. The IRB approval expiration date has been stamped on the informed consent document. Please keep copies of the consent forms used for this research for three years after the completion of the research.

Continuing Review: If you want to continue to collect data from human subjects or analyze data from human subjects after the expiration date for this approval, you must submit a renewal application to the IRB Office at least 30 days before the approval expiration date.

Modifications: Any changes to the approved protocol must be approved by the IRB before the change is implemented except when a change is necessary to eliminate apparent immediate hazards to the subjects. If you want to modify the approved protocol, please submit an IRB addendum application to the IRB Office.

Unanticipated Problems Involving Risks: You must promptly report any unanticipated problems involving risks to subjects or others to the IRB Manager at 301-405-0678 or jsmith@umresearch.umd.edu.

Student Researchers: Unless otherwise requested, this IRB approval document was sent to the Principal Investigator (PI). The PI should pass on the approval document or a copy to the student researchers. This IRB approval document may be a requirement for student researchers applying for graduation. The IRB may not be able to provide copies of the approval documents if several years have passed since the date of the original approval.

Additional Information: Please contact the IRB Office at 301-405-4212 if you have any IRBrelated questions or concerns.

Appendix 2

Instructions Given to Participants for Using the Self-Assessment Manikin

Today I will be showing you some pictures. We need to know how you feel when you see these pictures. There are no wrong answers. Whatever you feel is the right answer to give. To help you tell us how you felt when you saw each picture, we are going to use SAM. SAM has helped lots of people tell researchers how they feel. After you see each picture, you will be able to tell us how you felt when you looked at it by telling us the number that goes with the picture of SAM that best shows how you felt.

(Show child the valence SAM). Looking at this screen, you see 5 pictures of SAM. Notice that on one side, SAM is frowning and on the other side, SAM is smiling, and in the middle SAM is not smiling or frowning. These pictures are in order from a very unhappy SAM to a very happy SAM. (Point to #9) This picture of SAM shows him smiling very big. This is what you would choose if the picture you had just seen made you feel happy, glad, cheerful, pleased, good, or hopeful. You would let us know that you had chosen this picture by telling us the number that is under the picture of SAM, so for this one you would choose "9". (Point to #1). This picture shows SAM frowning. This is what you would choose if you felt unhappy, scared, angry or bad. If you feel neutral, that is you didn't feel either happy or unhappy, then you can choose the number that goes with the picture of SAM that is not smiling or frowning. (Point to #5). If you felt in between being very happy and a little bit happy, you would choose the number that goes between pictures of SAM.

Now let's look at the second feeling. (Show child the arousal SAM).

(Point to #1) Here is SAM when SAM is very still and his eyes are closed. You would use this SAM if you felt very calm, relaxed, bored or sleepy. You would use the SAM on the other side if you felt very excited, nervous, jittery, active, or wide awake. Notice how it looks like SAM is jumping up and down and his stomach is excited. This is like when you get excited and can't sit still or like you have butterflies in your stomach when you are very nervous. Use this to tell how exited or calm you felt when you saw the picture. If you are very excited, enthusiastic, nervous, scared or wide awake, you would choose "9". If you feel calm, relaxed or sleepy you would choose "1". Just like in the first set, you can choose the number that goes between the pictures of SAM.

Footnotes

[1]A second method (termed “arousal by rank”) assigned the top twenty of each child’s arousal responses to the high arousal condition, and the bottom twenty to the low arousal condition. In cases where this did not break down evenly (for example, if there were 25 responses for “low” arousal), a random subset was selected so that the high and low arousal by rank categories each had twenty pictures. This was done in order to address the possibility that some children may not have been using the scale appropriately, as they were not using the whole scale. A second set of analyses was conducted with these low and high ratings. Results were found to be largely similar to those seen in the analyses reported above and thus are not presented due to space considerations.

[2] In addition to examining valence-hits and description-hits, a third source measure in which both were met (referred to as “source hit-description and valence”) was also analyzed. Overall, the pattern of these results was similar to that seen for source hit-description, although the means were lower overall. Due to space considerations, these results are not included in the present report.

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