Early Positive Parenting and Maternal Depression History Predict Children's Relational Binding Ability at School-Age

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Abstract

Research has indicated age-related improvements in relational binding, an important process of episodic memory, across development. However, little research has focused on individual differences in relational binding and factors contributing to this variation. Although differences may arise from various sources, early caregiving has been shown to impact aspects of memory related to relational binding and also the hippocampus, a structure critical to binding. The present study investigated the influences of early and concurrent parenting and maternal lifetime depression history on children's ability to successfully bind details and retain this information across a delay. A total of 97 children are included in this report. Children were part of a longitudinal study with testing at preschool age (Time 1: 3-5 years) and school age (Time 2: approximately 3 years later). At both time points, positive and negative parenting behaviors were assessed during observational parenting tasks and maternal depression history was assessed with a clinical interview. At Time 2, a composite binding score was derived from two episodic memory tasks: a source memory task and a feature binding task. Findings indicated that early positive parenting predicted higher binding scores later in childhood whereas maternal depression was associated with lower scores. These results were robust even after taking into account child age, general cognitive ability, race, and parental education. These findings highlight two factors related to the caregiving environment, parenting and maternal depression, that contribute to individual differences in children's relational binding ability and underscore the importance of early experience on episodic memory development.

Keywords: Relational Binding, Episodic Memory, Parenting, Maternal Depression, Cognition

Introduction

Episodic memory, a type of long-term memory for events and the accompanying contextual details, allows us to recall rich spatial and temporal details of past experiences and is vital to creating our personal identity (Tulving, 1972). Age-related improvements in episodic memory have been well documented, beginning in infancy and extending throughout adolescence (Bauer, 2015; Sluzenski, Newcombe, & Kovacs, 2006). One component of episodic memory that shows significant development in early childhood is relational binding, a process through which items or details of events are bound together (Cohen & Eichenbaum, 1993). This process is critical to episodic memory as it integrates items and their surrounding context and aides in children's ability to form and recall memories for life events (Olson & Newcombe, 2014). Evidence from neuroimaging studies suggests relational binding is dependent on the hippocampus. Specifically, research in adults shows greater hippocampal activation for items encoded together rather than encoded separately (e.g., Davachi & Wagner, 2002; Davachi, 2006; Henk, Buck, Weber, & Wieser, 1997). In children, developmental changes in this ability are argued to result from structural and functional changes in the hippocampus (Olson & Newcombe, 2014; Riggins, 2012). Although age-related improvements in relational binding are evident across childhood, large individual differences are also apparent and remain under-investigated. These differences are meaningful, as binding has been shown to be important in multiple real-world domains, including academic achievement in children (Hassavort, Khan, Hillman, Kramer, & Cohen, 2018).

Parenting and Memory in Children

Social factors reflect a potential source of variability leading to individual differences in relational binding, as early caregiving impacts certain forms of memory (e.g., autobiographical

memory; Larkina & Bauer, 2010; Farah et al., 2008; Valentino et al., 2014) and also the hippocampus (Blankenship, Chad-Friedman, Riggins, & Dougherty, 2019; Luby et al., 2012; Rao et al., 2010). For example, both positive parenting practices (e.g., sensitive, responsive, supportive caregiving) and negative parenting practices (e.g., hostile and intrusive caregiving) serve important roles in shaping children's autobiographical memory, a specific subtype of episodic memory for personal life events that typically requires the binding of various contextual details (Cleveland & Reese, 2005; Nelson, 1993; Reese, 2002). Specifically, children of mothers who converse more (high elaborative mothers), especially about life events, tend to form more specific and cohesive narratives than children of mothers who do not engage in such conversations (Valentino et al., 2014). Other forms of positive parenting practices, including supportive parenting, are also linked to differences in children's autobiographical memory, such that preschool-aged children of mothers who provide greater verbal, emotional, and behavioral support can better tell a narrative about a personal past experience compared to children of less supportive mothers (Larkina & Bauer, 2010).

In contrast to specific memories of children with supportive, high elaborative mothers, a phenomenon referred to as *overgeneral autobiographical memory* is evident in populations of children exposed to extreme negative parenting practices, including abuse or neglect (Moore & Zoellner, 2007; Valentino, 2011; Valentino, Toth, & Cicchetti, 2009). Specifically, neglected children's narratives lack specificity in temporal and spatial details (Moore & Zoellner, 2007). Although the exact mechanism linking extreme negative parenting and overgeneral memory is not fully known, research suggests that, in some cases, less detailed memories may serve as a coping mechanism to protect against remembering painful events (Moore & Zoeller, 2007).

The majority of research investigating associations between parenting and memory has focused on autobiographical memory. However, some research has shown associations between parenting and other aspects of episodic memory more generally. For example, one longitudinal study using a sample of children living in a low socioeconomic status (SES) environment assessed the effect of positive parenting (using a measure of parental nurturance) in early childhood on recognition memory performance in middle childhood (Farah et al., 2008). In one recognition task from this study, children were told words by an experimenter and instructed to point to the picture associated with the word. Children were unaware they would be tested on the words. Later, at retrieval, children indicated which words they remembered hearing earlier in the session. Results from this study showed that early positive parenting related to superior performance on the recognition memory task. These findings suggest that effects of early caregiving may not be specific to autobiographical memory, but impact other types of memory as well (e.g., recognition memory).

Parenting and the Hippocampus in Children

A related line of research highlights the role of early caregiving in the development of the hippocampus, both in humans and animals. Positive and negative parenting practices are thought to differentially impact hippocampal volume by altering the neurodevelopmental process of synaptogenesis (Liu, Diorio, Day, Francis, & Meaney, 2000). Positive parenting traits early in development have been associated with increased hippocampal volume later in development (Belsky & de Haan, 2011; Luby et al., 2012, cf. Rao et al., 2010). In contrast, negative parenting practices have been associated with reduced hippocampal volume (e.g., Blankenship et al., 2018; Lee et al., 2018; Little et al., 2015). Finally, it has been argued theoretically (Tottenham & Sheridan, 2009) and shown empirically (Blankenship et al., 2018; Humphreys et al., 2019; Luby,

Belden, Harms, Tillman, & Barch, 2016) that the preschool years may be a sensitive period for the effects of parenting on hippocampal development, as a great deal of brain development occurs during this period. Given associations between parenting and the structure of the hippocampus, it is likely that early parenting impacts processes dependent on the hippocampus, including relational binding, especially in early childhood.

Maternal Depression and Memory in Children

Depressed individuals (van Vreeswijk & de Wilde, 2004) and children of depressed mothers (Woody, Burkhouse, & Gibb, 2015) also report memories that are overgeneral, similar to findings in neglected children. It has been proposed that these overgeneral memories may serve as a marker for depression before symptoms emerge, and contribute to the inter-generational transmission of depression (Sullivan, Neale, & Kendler, 2000; Weissman et al., 2006; Woody et al., 2015). Thus, differences in memory in the offspring of mothers with a history of depression may represent a familial or genetic vulnerability for depression and accompanying memory deficits.

Maternal depression is also known to alter parenting (e.g., Baker & Iruka, 2013; Dougherty, Tolep, Smith, & Rose, 2013). Depressed mothers tend to converse less with their children and exhibit disruptions in parenting, which is characterized by greater negative affect, greater hostility, less support, and less sensitivity (Lovejoy, Graczyk, O'Hare, & Neuman, 2000). Studies have also highlighted that early parenting may moderate the association between depression, stress physiology, and behavioral outcomes (Dougherty, Klein, Rose & Laptook, 2011; Dougherty et al., 2013). Given the increased risk for overgeneral memories and the impact of depression on parenting, maternal depression may also amplify the impact of negative parenting practices on memory. In other words, negative parenting may be particularly

detrimental to children who are already at-risk for depression and its accompanying memory impairments. Unfortunately, limited research has investigated a link between maternal depression and children's memory ability and no research has focused on other aspects of memory, such as relational binding.

Present Study

In this study, we focus on investigating associations between variations in parenting, maternal depression, and children's ability to bind contextual details using a longitudinal sample of children and their parents. Parenting and maternal depression were assessed during the preschool years (i.e., 3-5 years) and ~3 years later; children's binding ability was assessed at the follow-up assessment only. We focus on childhood because effects of parenting and maternal depression tend to be strongest early in life when the brain is especially susceptible to variations in the environment and when children are most reliant on their caregivers for support (Bradley et al., 1989; Fox, Levitt, & Nelson, 2010). Although associations have been noted between parenting, depression, and aspects of memory more generally, gaps remain in the literature. Notably, relational binding has not been assessed, specific dimensions of parenting (i.e., positive and negative) have not been assessed in the same study, and timing-dependent effects of parenting on components of episodic memory ability have yet to be fully elucidated.

The first aim of this study was to explore relations between variations in parenting and children's relational binding ability. We assessed positive and negative dimensions of parenting to capture the unique contributions of specific dimensions of parenting to memory. To understand the impact of timing of parenting, we investigated both early and concurrent parenting. We hypothesized that positive and negative parenting would differentially impact relational binding such that high levels of positive parenting would be associated with higher

binding scores and high levels of negative parenting would be associated with lower binding scores. Given the known effects of the early environment on development, we hypothesized that early parenting would more robustly predict binding than concurrent parenting.

The second aim of this study was to investigate the impact of maternal lifetime history of depression on offspring's memory ability. We hypothesized that children whose mothers had a history of depression would have lower binding scores than children whose mothers did not have a history of depression.

A third aim of this study was to assess moderated effects of parenting and maternal depression on memory development given that previous studies have suggested that parenting and depression may share complex associations (e.g., Baker & Iruka, 2013; Dougherty et al., 2013). Given that research shows that maternal depression interacts with disruptions in parenting and that this predicts both stress physiology and behavioral outcomes (Dougherty et al., 2011, 2013), we hypothesize that maternal depression in combination with disruptions in parenting (either high negative or low positive) would show the greatest impacts on children's relational binding ability.

The present study will add to the existing literature by elucidating two factors, early parenting and depression, which may contribute to individual differences in children's ability to bind items in episodic memory in childhood. Understanding specific factors that contribute to memory development is important as it is a core process that is not only important for children's ability to form memories, but is also integral to academic success.

Methods

Participants

At Time 1, preschool-aged children and their biological parents were recruited through the use of flyers distributed to local schools, daycares, and healthcare providers. We also specifically advertised for parents who had a lifetime history of depression through targeted flyers, as the study was designed to examine risk for depression in early childhood. The sample was monitored to ensure that it consisted of at least 50% of participants with depression history. Participants were screened on the phone and were not included in the study if children had a developmental disability, parents met criteria for bipolar disorder or psychotic disorder, or at least one parent did not speak English. At Time 1, 175 participants were enrolled, and 104 participants returned to the laboratory for a follow-up assessment at Time 2. The present study focuses on a subset of these participants (n = 97) who completed the tasks included in this report (i.e., parent-child interaction tasks and the memory tasks). One family did not complete the parent-child interaction task at Time 2; thus, analyses involving parenting at Time 2 include 96 participants (Dougherty et al., 2013; Merwin, Smith, Barrios, Lemay, & Dougherty, 2018).

The sample of participants was racially diverse (46.4% White, 35.1% African American, 1% Asian, 7.2% Multiracial, 8.2% Other Race, and 2.1% chose not to identify). Household income was also diverse (5.2% <$20,000; 7.2% $20,001-40,000; 21.6% 40,001-70,000; 29.9% $70,001-$100,000; 33% >$100,000, 3.1% did not provide a response). At Time 1, participants were 3-5 years old (M = 4.22, SD = 0.08, 47 females). Testing at Time 2 was conducted when children were 5-10 years old (M = 7.30, SD = 0.10, 46 females). Although the follow-up visit occurred approximately 3 years later for most children (M = 37.02 months, SD = 6.45, range = 25.54 - 52.47), the gap between visits was longer for some children. Analyses revealed that participants who took part in the longitudinal follow-up and are included in the current subsample (n=97) did not differ significantly from participants who did not complete the follow-

up assessment (n=78) on sex (χ^2 (1, N = 175) = 0.13, p = .72), child age (t(173) = 1.13, p = .26), general cognitive ability (t(171) = 0.45, p = .65), positive parenting (t(159) = 1.62, p = .11), negative parenting (t(159) = 0.95, p = .34), or maternal depression history (χ^2 (1, N = 167) = 2.05, p = .15).

Procedure

Testing occurred at two time points. At Time 1 and Time 2, observational parenting assessments were conducted where children and their parents completed a series of tasks modified from the Teaching Tasks Battery (Egeland et al., 1995) and mothers completed the Structural Clinical Interview for DSM-IV Disorders (SCID; First, Spitzer, Gibbon, & Williams, 1996). Children's general cognitive ability was assessed at Time 1 using the Block Design subtest of the Wechsler Preschool and Primary Scale of Intelligence (WPPSI; Wechsler, 2002). At Time 2, children completed two memory tasks thought to require relational binding: the Feature Binding Task (Lorsbach & Reimer, 2005) and the Source Memory Task (adapted from Ghetti, Mirandola, Angelini, Cornoldi, & Ciaramelli, 2011).

Informed written consent was obtained from parents, and assent was obtained from children 7 years and older. The University of Maryland IRB (Approval # 368073, "Maryland Stress and Emotion Study") approved all methods included in this study.

Observed parenting. Children and their primary caregivers (94.5% mothers) completed tasks as part of the Teaching Tasks Battery (Egeland et al., 1995). At Time 1, five age-appropriate tasks were administered: (1) Book Reading, a task where parents were instructed to read a picture book to their child, (2) Wheels, a task where parents were told to help their child name as many objects with wheels as possible, (3) Maze, a task where parents helped their child complete an Etch-A-Sketch maze without touching any lines in the maze, (4) Story, a task where

parents helped their child arrange cards in the correct temporal order to depict a sequence of events, and (5) Tangoes, a task where children matched geometric pieces to predetermined shapes. At Time 2, four age-appropriate tasks were administered: (1) Guessing Game, a task where parents helped their child guess an image on an unseen card, (2) Traffic, a task where parents helped their child shift toy cars up/down and left/right on a board to clear a path, (3) Maze, a task where parents helped their children guide a marble into holes on a wooden labyrinth board, and (4) Block Buddies, a task where parents helped their child put together plastic shapes to mirror designs shown on a card.

Each task was rated on the following dimensions at both Time 1 and Time 2: maternal intrusiveness (interference with the child's needs, desires, interests, or actual behaviors), maternal hostility (expression of anger towards or rejection of the child), maternal support (expression of positive regard and emotional support to the child), maternal negative affect (frequency and intensity of negative affect including facial, vocal, and body language), and maternal positive affect (frequency and intensity of positive affect including facial, vocal, and body language). Maternal intrusiveness, hostility, and support were coded using a 5-point scale. Maternal negative and positive affect were coded on a 3-point scale. Scores were then averaged across tasks and standardized to *z* scores. *Z*-scored values were then averaged to form two composite variables: positive parenting composite and negative parenting composite. The positive parenting composite included maternal support and positive affect while the negative parenting composite included maternal intrusiveness, hostility, and negative affect.

The coding procedure for all tasks is described in (Dougherty et al., 2011; 2013). A detailed coding manual adapted from Egeland and colleagues' Teaching Tasks Battery (1995) was used to code each task. Two coders independently coded each task. The principal

investigator trained two graduate students in the administration and coding of the task using previously rated videos. Once the graduate students reached 80% accuracy, they trained undergraduate research assistants until the assistants reached 80% reliability. Weekly coding meetings were utilized to prevent rater drift.

The internal consistency (α) of the scales was acceptable (Time 1 negative parenting: α = .75; Time 1 positive parenting: α = .88; Time 2 negative parenting: α = .73; Time 2 positive parenting: α = .85). Inter-rater reliability was based on 38 video recordings at Time 1 and 28 video recordings at Time 2. The master coder coded all of the parent-child interaction videos at Time 1 and Time 2 included in the reliability set. The second coder was another individual who coded a subset of the full sample that the master coder completed in order to assess reliability between these coders. The intraclass correlation coefficients (ICC) were deemed to be excellent (Time 1 negative parenting: ICC = .97; Time 1 positive parenting: ICC = .96; Time 2 negative parenting: ICC = .96; Time 2 positive parenting: ICC =.91; for ICC values for specific coded dimensions, see Table S1).

Maternal depression. The Structured Clinical Interview for DSM-IV (SCID-NP; First et al., 1996) was administered at Time 1 and Time 2 to children's biological mothers. A master's level rater conducted the interviews via telephone, a method shown to have similar results as face-to-face interviews (Rohde, Lewinsohn, & Seeley, 1997). Lifetime major depressive disorder and dysthymic disorder were collapsed into one category to represent lifetime history of depressive disorder. Based on findings from the interviews at Time 1 and Time 2, lifetime history of depressive disorder was indicated as present or absent. Fifty-seven (59%) mothers had a history of depressive disorder at Time 1 and/or Time 2. Four mothers met criteria for a current depressive disorder at the Time 2 SCID interview. Based on recordings of 16 SCID interviews at

Time 1 and 10 SCID interviews at Time 2, the kappa for inter-rater reliability was 1.0 at Time 1 and Time 2 assessments.

Current depressive symptoms at Time 2 were assessed using the self-report Diagnostic Inventory for Depression (DID; Zimmerman, Sheeran, & Young, 2004) completed by mothers. This variable was used to isolate the effect of maternal lifetime history of depression on binding and to ensure that effects were not due to current depressive symptoms. The internal consistency (α) of the DID was good (α = .88). In addition to providing necessary information regarding the impact of depression on memory, the depressed sample in this study also presented more variation in parenting behaviors, which aided us in thoroughly investigating the role of parenting on individual differences in children's binding ability.

General cognitive ability. General cognitive ability was assessed at Time 1 using the Block Design subtest of the WPPSI (Wechsler, 2002), a standardized age-appropriate intelligence test. Children's scaled score was calculated and used as a covariate in analyses to ensure that effects of parenting were specific to memory and were not due to overall differences in general intelligence. One child did not complete the Block Design subtest; thus, 96 participants provided general cognitive ability data at Time 1.

Relational binding ability. The Feature Binding Task (adapted from Lorsbach & Reimer, 2005) and Source Memory Task (adapted from Ghetti et al., 2011) were administered at Time 2, as these measures of memory were appropriate for school-aged children, but not younger children. Previous work has shown that these memory tasks tap relational binding. In turn, an a priori decision was made to combine these tasks to form a composite score. Specifically, accuracy scores from these tasks were standardized into z-scores and averaged to create a composite binding score, which was used in all analyses involving memory. The composite

binding score provided a more robust way to assess child memory and also ensured that the results were not specific to one task. Raw accuracy scores from each task were moderately correlated (r = 0.32, p = .002).

Feature Binding Task. This task was adapted from the original version used in Lorsbach and Reimer (2005). Minimal changes were made to ensure that the task would be adequate to use in the age range included in our sample. Specifically, we created our own stimuli that matched the stimuli described by Lorsbach and Reimer (2005). We used a 4 s retention interval rather than an 8 s retention interval as was used in the original task. We also changed the timing for the slide preceding each trial. Specifically, the word "Ready" was shown for 1 s at the beginning of each trial rather than the word "Study" for 500 ms as was done in the original version of the task.

During the task, children were shown a 3 X 3 grid of squares presented on a computer screen. The stimuli consisted of the following 8 objects: frog, pumpkin, lion, fish, kite, balloon, snowman, and heart. Prior to the presentation of the stimuli for each trial, the word "Ready" was displayed on the screen for 1 s. Then, three different objects were sequentially presented on the grid in different squares for 1 s each. Following the presentation of the three objects for each trial, a question mark was displayed on the screen for 4 s before the test item was shown. For the test item, an object was presented in a square on the grid along with the words "Yes/No?" The child was instructed to say "yes" if he/she saw the item in the specified square during the preceding trial and "no" if he/she did not see the item in the specified square during the preceding trial. The test item remained on the screen until the child verbally responded. The experimenter recorded the child's verbal responses to each memory test via a button press on the computer, with 1 indicating "yes" and 2 indicating "no". Following the test item, there was a 2 s intertrial interval before a new trial began.

Children first completed an item only block of 16 trials, where they were only asked to recall the stimuli they saw. Next, they completed a location only block of 16 trials, where they were only asked to recall the square in which they saw the stimuli. Finally, they completed an object/location combination block of 32 trials in random order. Prior to the beginning of each block, participants completed 2 practice trials. Fifty percent of the trials were "old" meaning that the child had seen the object, location, or object/location combination during the preceding trial and 50% of the trials were "new" meaning the child had not seen the object, location, or object/location combination during the preceding trial. In this task, the ability to integrate memory for items and their respective locations is thought to rely on relational binding. Accuracy was calculated as the proportion of trials from the object/location combination block where the child accurately responded to the memory test out of the total number of trials.

Source Memory Task. This task was adapted from Ghetti et al. (2011). Changes were minimal, but were again done to ensure that the task was adequate for use in our age range. We again used stimuli that were similar to, but not identical to, the original study. In addition, we changed the semantic questions that were asked during encoding as we thought our English-speaking participants would more easily understand them. We also decreased the number of stimuli to 60 stimuli and presented stimuli for 1.5 s rather than 2 s. Recall was tested after a delay (filled with other tasks) as opposed to immediately following encoding. In the original task, participants were asked if the object was red or green and to rate their confidence in their response to each question. These questions were not asked in the adapted version of the task, as they were not of primary interest in our study.

Children first completed an implicit encoding phase, during which they were required to make judgments about objects, followed by a retrieval phase. During each encoding trial,

children were shown an object presented on a computer screen for 2 s and were then asked to make a decision about the object. Depending on which block it was, they were either asked to decide if the object was living or not living (Living/Not Living), could fit or not fit in a shoebox (Fit/Not Fit), or was soft or hard (Soft/Hard). The question was displayed on the screen until the child provided a response. Blocks were presented in counterbalanced order. The experimenter recorded the child's verbal responses to each question by pressing the appropriate button on the keyboard. Children first completed 12 practice trials followed by 30 test trials, evenly divided among the 3 categories.

Immediately following encoding, children were asked to recall as many of the 30 objects they could remember to promote encoding. After a delay of 35-60 minutes, children completed the retrieval phase of the task. During each trial, children were shown an object and were asked if the object was "old" (shown during encoding) or "new" (not shown during encoding). The experimenter recorded the child's response with the appropriate button press (1 for "old, 2 for "new"). If the child replied with "old", they were further asked if they remembered the object or if it was simply familiar to them[1] and to recall the source of the object. Specifically, they were asked to recall which block the object appeared in during encoding (i.e., Living/Not Living, Fit/Not Fit in Box, Soft/Hard). Each trial lasted until the child gave a response. Relational binding is thought to support children's ability to integrate memory for both the item and the type of block in which it appeared (e.g., Living/Not Living). Participants completed 8 practice trials and 60 experimental trials (30 old, 30 new) during retrieval. Their source memory score was recorded as the proportion of trials where they both correctly recalled old items and made

[1]Data from the remember/familiar decision was not included in the present study as it is a subjective assessment of memory and accuracy cannot be objectively verified.

the correct source judgment out of all correct item trials (old). Source memory data from one participant was excluded from analyses due to a poor understanding of task instructions; specifically, the participant responded "new" for all old/new judgments.

Statistical Analysis Plan. Time 2 age, time between assessments, Time 1 general cognitive ability, gender, race (white vs. non-white), and parental education (at least one parent with a 4-year college degree vs. neither parent with a 4-year college degree) were examined as potential covariates. Only covariates significantly correlated with the dependent composite binding variable were included in analyses (see Table 2). These variables included Time 1 general cognitive ability, Time 2 age, race, and parental education.

Associations between early (Time 1) and concurrent (Time 2) parenting, maternal lifetime depression, and children's Time 2 composite binding score were first assessed via bivariate correlations (Table 2). Second, significant correlations were followed up with separate linear regressions examining the effects of each parenting variable and maternal lifetime depression on binding ability, controlling for significant covariates. Lastly, to further understand the unique effects of parenting and maternal lifetime depression and the timing-dependent effects of parenting on binding, we conducted a multiple linear regression. Specifically, the composite binding score was entered as the dependent variable and Time 1 and Time 2 positive and negative parenting, maternal lifetime depression history (coded absent vs. present), and current depressive symptoms were entered as the independent variables. Time 2 age, Time 1 general cognitive ability, race, and parental education were entered as covariates.

Finally, we assessed potential moderated effects involving maternal lifetime depression history, parenting, and children's binding ability. A linear regression was used to examine interactive influences of maternal lifetime depression and early and concurrent parenting on the

composite binding score. In this model, Time 2 age, Time 1 general cognitive ability, race, and parent education were entered as covariates. The independent variables included Time 1 and Time 2 positive and negative parenting, maternal lifetime depression, and the four interaction terms between parenting and maternal lifetime depression (i.e., Time 1 positive parenting X maternal depression, Time 1 negative parenting X maternal depression, Time 2 positive parenting X maternal depression, Time 2 negative parenting X maternal depression).

Results

Descriptive statistics and bivariate correlations for parenting measures, depression measures, memory measures, and covariates are presented in Table 1 and Table 2, respectively. Maternal lifetime depression history was not related to any of the parenting measures, but was significantly associated with lower composite binding scores. Greater Time 1 positive parenting was significantly associated with higher Time 2 composite binding scores, whereas greater Time 1 negative parenting was significantly associated with lower Time 2 composite binding scores. Neither Time 2 positive nor Time 2 negative parenting were significantly correlated with the composite binding score.

Parenting, maternal depression, and relational binding in children. In separate models, Time 1 positive parenting (b = 0.40, SE = 0.18, p =.03) and maternal depression (b = -0.65, SE = 0.29, p =.03) remained significant predictors of children's binding at Time 2 after controlling for Time 2 age, Time 1 general cognitive ability, race, and parental education. Time 1 negative parenting was no longer a significant predictor of children's binding after controlling for covariates (b = 0.02, SE = 0.19, p =.93). Results from the multiple linear regression assessing Time 1 and Time 2 positive and negative parenting variables, maternal lifetime depression, and maternal current depressive symptoms at Time 2 showed that this full model accounted for 30%

of the variance in the composite binding score (Table 3). In addition, Time 1 positive parenting significantly predicted higher composite binding scores above and beyond Time 1 and Time 2 negative parenting, Time 2 positive parenting, and maternal depression. Results showed that maternal depression was marginally significantly associated with children's composite binding score in the multivariate model (p = .056). Multicollinearity analyses revealed VIFs that ranged from 1.17-2.58, which is in the acceptable range of .1-10 (Field, 2009; Kutner, Nachtsheim, & Neter, 2004).

Moderated effects of parenting and maternal lifetime depression history on relational binding in children. A linear regression was used to test two-way interactive effects of Time 1 and Time 2 positive and negative parenting and maternal lifetime depression on children's composite binding score. Multicollinearity statistics were shown to be 1.12 – 2.29, which is within the acceptable range. No significant interactions were observed between maternal depression and Time 1 positive parenting (b = -0.30, SE = 0.43, p =.50), maternal depression and Time 1 negative parenting (b = -0.57, SE = 0.43, p =.19), maternal depression and Time 2 positive parenting (b = -0.08, SE = -0.41, p =.84), and maternal depression and Time 2 negative parenting (b = 0.83, SE = 0.58, p = .16).

Discussion

In this study, we investigated two factors, parenting and maternal depression that may contribute to individual differences in children's relational binding ability, an important process of episodic memory. Specifically, we found that associations exist between early parenting, maternal depression history, and children's relational binding ability later in childhood. Early positive and negative parenting showed associations with binding ability three years later, such that higher levels of positive parenting were associated with higher binding scores, whereas

higher levels of negative parenting were associated with lower binding scores. However, only early positive parenting remained a significant predictor of binding after taking into account effects due to child age, general cognitive ability, race, parental education, and concurrent parenting. In addition, results suggest that children of mothers with a history of depression performed worse on the memory tasks than did children of mothers without this history.

Although parenting and maternal depression both predicted children's binding ability, these variables were not correlated and there were no moderating effects between parenting and maternal depression and their relation with children's binding ability. When included in the same model, maternal lifetime depression marginally significantly predicted children's binding ability while Time 1 positive parenting remained a significant predictor of binding. These results suggest that parenting and maternal depression may independently influence variability in children's binding ability. Given our sample size and limited power to investigate large multivariate models, future studies are necessary to investigate these unique effects in larger longitudinal samples.

Parenting and Memory in Children

Results examining parenting provide important information regarding both the timing and type of parenting that influences relational binding. Timing dependent results add to a growing body of literature, which stresses the importance of the early environment on cognitive development (Bradley et al., 1989; Fox et al., 2010). Given that early parenting, but not concurrent parenting influenced binding, it is apparent that early experiences associated with parenting are particularly important to memory development, specifically relational binding ability, and the effects of these early experiences persist for several years. These impacts of early, but not later parenting may be explained through an understanding of the developmental

trajectory of relational binding. Specifically, this process develops fairly rapidly in early childhood with large gains between the ages of 4 and 6 years relative to other periods in development (e.g., Riggins, 2014; Sluzenski et al., 2006). Therefore, early parenting may impact binding more robustly in early childhood when this process sees its largest gains. Although this early impact on the brain during a period of accelerated memory development may provide an explanation for why later, concurrent parenting did not impact children's memory, it is also possible that it takes several years for effects on memory to be observed. Future research would benefit from assessing whether parenting in middle childhood impacts memory later in adolescence.

In addition to elucidating timing dependent effects of parenting on relational binding, the present results suggest that effects of positive parenting are particularly robust, as they held after controlling for potential confounding factors (such as general cognitive ability). Existing research has highlighted the importance of positive parenting on processes related to relational binding, such as autobiographical memory (Cleveland & Reese, 2005; Nelson, 1993; Reese, 2005). In addition, some research has suggested a link between positive parenting and recognition memory later in childhood in children raised in low-SES environments (Farah et al., 2008). The present study extends this research by highlighting an additional aspect of memory, relational binding, that is impacted by variation in early caregiving. Furthermore, this study provides specificity of results by including negative parenting measures as the previously mentioned studies primarily examined facets of positive parenting. In general, early positive parenting may be particularly important to the development of relational binding during early childhood as it may serve as a supportive factor especially during periods of rapid development.

The present study did not investigate a mechanism linking parenting to relational binding, as we were first interested in laying the groundwork for a link between parenting and relational binding. However, prior research enables us to hypothesize that positive parenting may influence the development of this cognitive process through impacts on both the child's environment and the developing brain. In terms of the former, positive parenting provides children with enhanced environments that encourage learning. Children's play with mothers tends to last longer and is more varied and complex in nature than solitary play, providing the child with more opportunities to learn (Tamis-LeMonda, Uzgiris, & Bornstein, 2002). Therefore, children of mothers who are supportive and sensitive to their child's needs may have more opportunities to develop their ability to successfully bind items in memory. Furthermore, research shows that parents who are more sensitive to their children's needs converse with their children more about everyday events (Larkina & Bauer, 2010; Reese, Haden, & Fivush, 1993), which may help solidify memories, and in turn, benefit memory development.

Parenting also impacts the development of the hippocampus (Belsky & de Haan, 2011; Blankenship et al., 2018; Luby et al., 2012, Rao et al., 2010). While the hippocampus is known to be highly important to general memory processing (Eichenbaum, 1999), it is thought to be specifically important for binding the details of representations to form episodic memories (Cohen et al., 1999; Davachi, Mitchell, & Wagner, 2003). Although a mechanism linking parenting and memory via the hippocampus has not, to our knowledge, been documented in humans, this mechanism does exist in rodents. Specifically, the tactile stimulation associated with sensitive parenting, in particular maternal licking and grooming, promotes synaptogenesis in the hippocampus and relates to superior performance on tasks assessing spatial memory, including the Morris water maze (Liu et al., 2000). Rodents who do not receive such stimulation

have smaller hippocampal volumes and exhibit poorer performance on the spatial memory tasks. Given these findings in rodents and the known effects of caregiving on the hippocampus in humans, a similar mechanism linking parenting and memory likely exists in humans.

Maternal Depression and Memory in Children

Children of mothers with a history of depression exhibited poorer relational binding than children of mothers without such a history. Maternal depression has long been shown to have a detrimental impact on child development, with studies indicating the adverse effect of maternal depression on cognitive development (Kurstjens & Wolke, 2001), emotion regulation (Hoffman, Crnic, & Baker, 2006), and the development of externalizing and internalizing disorders (Goodman et al., 2011; Weissman et al., 2006), among other outcomes. The present results are in line with these studies and highlight relational binding as an additional facet of child development that is adversely impacted by maternal depression. These results also support recent research, which suggests a link between depressive symptoms in early childhood and memory ability in adolescence (Barch, Harms, Tillman, Hawkey, & Luby 2019).

The absence of interacting effects between depression and parenting suggests that the presence of maternal depression history impacts children in a similar way regardless of the levels of positive or negative parenting they are exposed to. However, it is important to note that we did not explore three-way interactions between parenting and depression or additional two-way interactions between the parenting variables, as we only had a small sample size that was not conducive to detecting these effects.

Interestingly, depression history was not associated with observed parenting in this study, which suggests that maternal depression may impact offspring memory through mechanisms independent of parenting. Future work would benefit from testing mediated effects of parenting

on the relation between maternal depression and binding to thoroughly understand the association between these factors. In line with the current findings, research has shown that maternal depression, in the absence of disruptions in parenting, confers risk for a large number of negative health and educational outcomes and functional impairment in offspring (Garber & Cole, 2010; Velders et al., 2011). Therefore, the mechanisms linking depression and binding may be due to genetic vulnerability or the large number of characteristics associated with maternal depression, including socioeconomic adversity and increased stress exposure.

Limitations and Future Directions

The longitudinal design and observational parenting measures in the present study allowed us to investigate associations between parenting and relational binding and to elucidate factors contributing to individual differences in this ability in children. However, as binding was not assessed at Time 1, we cannot conclude that children did not have differences in this ability at baseline. Furthermore, in this study, we focused on the successful formation of bound memories; however, examining errors (i.e., unsuccessful attempts to bind information) can also provide insight into mechanisms underlying failures in memory. Thus, future work would benefit from examining both successful and unsuccessful memory formation in relation to parenting and depression. Finally, it is important to note that our study focused exclusively on mothers. Future research should extend this research by investigating whether similar results are found with paternal depression and offspring memory.

Although our results elucidate factors that impact relational binding in childhood, it is important to acknowledge that parenting and maternal depression likely do not impact all children's binding ability in the same way. Some children may be resilient to the effects of early caregiving and maternal depression, whereas other children may be more susceptible to subtle

differences in caregiving. The impact of parenting may also differ by race or SES as parenting practices differ across race. For example, previous research has shown that authoritarian parenting (characterized by high demandingness and low responsiveness) in African American households does not relate to detrimental effects in children as it does in Caucasian households (Dearing, 2004; Ispa et al., 2004; Tamis-LeMonda, Briggs, McClowry, & Snow, 2008). Although the present study was not designed to examine effects of SES and race, results suggest that the associations between depression, parenting, and memory may differ across groups, as race was a significant predictor of parenting and relational binding. Future work should explore these meaningful differences with regards to race. Future work should also investigate mechanisms linking parenting and maternal depression to memory in early childhood in order to identify children who may be at-risk for memory impairments. A promising avenue would be to investigate potential genetic, environmental, or neural mechanisms linking maternal depression and parenting to children's memory.

Conclusions

Overall, results provide support for two factors that contribute to individual differences in children's relational binding ability, parenting and maternal depression, and also support literature that stresses the importance of the early environment on overall cognitive development. Future research would benefit from exploring additional aspects of memory and factors that may influence memory development, including sleep, stress, and familial conflict. Increased understanding of the factors contributing to individual differences in memory will help parents and educators work to support children during a period when their memory undergoes rapid development and is particularly susceptible to outside influences. In sum, results provide an important step forward in understanding influences of early caregiving on episodic memory

development; and most importantly, they shed light on important factors contributing to individual differences in a critical memory process, relational binding ability, in children.

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Table 1.

Descriptive Statistics

		n	Mean	*SD*	Min	Max
1.	Time 1 child age (yrs)	97	4.22	0.83	3.00	5.92
2.	Time 2 child age (yrs)	97	7.31	0.93	5.57	10.00
3.	Time between assessments (mths)	96	37.02	6.45	25.54	52.47
4.	Time 1 general cognitive ability (standardized scores)	96	9.92	0.30	6.00	34.00
5.	Time 2 depressive symptoms	97	5.36	3.69	0.00	18.47
Memory Measures (z scores)						
6.	Feature binding accuracy	97	-0.004	0.98	-2.20	2.08
7.	Source memory accuracy	96	-0.02	1.00	-3.07	-2.01
8.	Time 2 composite binding score	96	-0.04	1.61	-3.70	3.99
Parenting Measures (z scores)						
9.	Time 1 positive parenting	97	0.13	0.91	-2.63	1.67
10.	Time 1 negative parenting	97	-0.06	0.95	-0.82	4.33
11.	Time 2 positive parenting	96	-0.01	1.00	-5.28	1.87
12.	Time 2 negative parenting	96	0.01	1.00	-0.69	4.95

Note. Time 1 general cognitive ability reflects standardized score on block design subtest of the WPPSI; Composite parenting and memory scores were created from standardized *z* scores across tasks.

Table 2.

Bivariate correlations between children's relational binding ability, parenting, maternal depression, and covariates.

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	T1 child age													
2	T2 child age	0.82***												
3	Time between assessments	-0.13	0.47***											
4	Sex[1]	0.07	-0.01	-0.13										
5	Race[2]	0.14	0.08	-0.08	-0.01									
6	Parental education[3]	0.09	0.13	0.08	0.15	0.29**								
7	T1 general cognitive ability	-0.02	-0.18	-0.17	-0.02	0.24*	0.32**							
Memory Measure														
8	T2 composite binding score	0.31**	0.36***	0.15	0.07	0.33***	0.24*	0.28**						
Parenting Measures														
9	T1 positive parenting	-0.01	0.16	0.29**	-0.13	0.27**	0.33***	0.14	0.34***					
10	T1 negative parenting	-0.21*	-0.24*	-0.10	-0.01	-0.44***	-0.43***	-0.19	-0.26*	-.54***				
11	T2 positive parenting	0.10	0.13	0.06	-0.07	0.29**	-0.15	0.08	0.19	.32***	-.49***			
12	T2 negative parenting	0.03	0.07	0.07	-0.11	-0.38***	-0.22*	-0.13	-0.14	-0.13	.52***	-.58***		
Depression Measures														
13	Maternal lifetime depression[4]	-0.09	-0.17	-0.15	0.02	-0.07	-0.02	-0.04	-0.27**	-0.14	0.10	-0.01	0.16	
14	T2 current depressive symptoms	0.21*	0.14	-0.08	-0.07	0	-0.04	-0.21*	0.01	-0.07	0	-0.01	0.09	0.32**

Note. $*p < .05$, $**p < .01$, $***p < .001$; T1 = Time 1; T2 = Time 2; Sex, race, and maternal depression are coded 0, 1. [1] 0 = Male, 1 = Female; [2] 0 = Non-White, 1 = White; [3] 0 = At least one parent with a 4-year college degree, 1 = Neither parenting with a 4-year college degree; [4] 0 = No maternal lifetime history of depression, 1 = Maternal lifetime history of depression.

Table 3.

Summary of regression analyses for Time 1 and Time 2 parenting and maternal depression predicting Time 2 composite binding score (*N* = 94).

Predictor	Model 1 *b (SE)*
T2 child age	0.58** (0.16)
T1 general cognitive ability	0.14** (0.05)
Race	0.50 (0.33)
Parental education	0.18 (0.40)
T2 depressive symptoms	0.04 (0.04)
T1 positive parenting	0.49* (0.21)
T1 negative parenting	0.35 (0.23)
T2 positive parenting	0.07 (0.19)
T2 negative parenting	-0.14 (0.21)
Maternal lifetime depression	-0.62† (0.32)
R^2	0.38
Adjusted R^2	0.30
F Statistic	4.93**

Note. ** $p < 0.01$, * $p < .05$, † $p < .06$; T1 = Time 1; T2 = Time 2.