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The Development of Children's Early Memory Skills

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Abstract

A multi-task battery tapping nonverbal memory and language skills was used to assess 60 children at 18, 24, and 30 months. Analyses focused on the degree to which language, working memory, and deliberate memory skills were linked concurrently to children's Elicited Imitation performance, and whether the patterns of association varied across the different ages. Language ability emerged as a predictor of *immediate* Elicited Imitation performance by 24 months and predicted *delayed* performance at each age. In addition to the contributions of language, the children's abilities to search for and retrieve toys in the deliberate memory task were associated with their *immediate* Elicited Imitation performance at each age. In addition to language, working memory was positively associated with aspects of both *immediate* and *delayed* performance at all ages. The extent to which it was possible to replicate and extend previous cross-sectional work in this longitudinal study is discussed.

Keywords

Cognitive development; Event memory; Deliberate memory; Nonverbal memory; Language skills; Longitudinal study; Working memory

Young children's behavior reveals their abilities to remember long before they can use language to describe their experiences. Evidence from tasks that tap different aspects of nonverbal memory – including conditioning (e.g., Rovee-Collier & Hayne, 2000) and elicited and deferred imitation (e.g., Bauer, Wenner, Dropik, & Wewerka, 2000; Meltzoff, 1995) –

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documents clearly the mnemonic competence of infants, as well as substantial improvements with age in various aspects of remembering. Moreover, the literature on early memory that has emerged in the last 20 years has (a) contributed to a reappraisal of the cognitive competencies of infants, (b) suggested continuities across development in the operation of basic memory systems, (c) fostered explorations of critical constructs such as reinstatement, and (d) provided a foundation for addressing long-standing controversies such as infantile amnesia (see Bauer, 2006, for a review).

Given these important contributions, as well as the fact that children's nonverbal memory skills may provide a platform for their later use of language to report the past (see Bauer, 2007; Ornstein, Haden, & San Souci, 2008), it is surprising that our understanding of the development of nonverbal memory is limited by two features of the literature. First, because the literature on early memory is based largely on cross-sectional studies, it is difficult to move from statements about age-related changes in performance to descriptions of the developmental course of remembering within individual children. In this regard, longitudinal investigations in which the same children are traced over time are essential for describing how early skills are related to later abilities (Ornstein & Haden, 2001; 2008). Second, when children's memory – verbal or nonverbal – is assessed, the emphasis typically is on describing remembering in the context of one or another paradigm, with within-subject multi-task assessment strategies being more the exception than the rule (but see DeMarie & Ferron, 2003; Lange & Carroll, 2003). Because different assessments can results in quite different impressions of young children's memory skills (Ornstein, Baker-Ward, & Naus, 1988; Ornstein & Myers, 1996), this is indeed unfortunate. Accurate characterization of children's changing skills requires that assessments include several tasks that vary in their information processing and effort requirements.

The present study is unique in coupling a multi-task assessment strategy with a longitudinal research design in which children were tracked over the first six years of life. The focus in this report is on the memory and linguistic skills of 60 children (representing one of two cohorts that have been followed) who were assessed at three time points: 18, 24, and 30 months. The particular age points were selected because they span a period marked by the development and consolidation of children's memory as it has been assessed nonverbally, along with the emergence of verbal recall. At each of the three age points, memory performance was examined in the context of three different nonverbal tasks that tap young children's changing event memory (Elicited Imitation; Bauer et al., 2000), working memory (Working Memory for Locations; Pelphrey & Reznick, 2003), and deliberate memory (Hide-and-Seek; DeLoache et al., 1985). Given the importance of examining developmental change in these skills, the primary aims of this investigation were to determine the extent to which children's abilities to reproduce modeled event sequences were associated *at each age* with their skills in language, deliberate memory, and working memory and to examine potential developmental changes in the linkages among these abilities.

The Elicited Imitation task was used to generate criterion measures because there is considerable agreement that toddlers' imitation of event sequences is based on memory processes that are comparable to the explicit memory skills revealed in older children's abilities to talk about past experiences and to prepare for deliberate assessments of remembering (Bauer, 2006; Ornstein et al., 2008). In addition, there is a rich literature on age-related differences in children's memory for action sequences that have been modeled for them (Bauer, 2007), and considerably more is known about young children's performance on the Elicited Imitation task than the Working Memory for Locations and Hide-and-Seek procedures. In the Elicited Imitation paradigm, remembering is demonstrated when a child uses props to reproduce a sequence of actions that had previously been modeled by an examiner. Consider, for example, the three actions involved in constructing a gong: putting a crossbar atop two posts, placing a metal plate on the crossbar, and then hitting the plate with a plastic mallet. After a baseline period, an experimenter demonstrates the actions required to construct the gong, typically with a verbal description of the behaviors and goal. Immediate and/or delayed memory for the modeled action sequences can be observed in the children's responses to prompts such as, "You show me how to make a gong." Using this method, Bauer (2007, Bauer et al., 2000) has reported a number of age-related changes in early memory, including substantial increases in how long memories seem to last, and in children's abilities to evidence ordered recall after various delay intervals. In addition, with increases in age, children are better able to remember longer sequences of actions for greater periods of time. Perhaps most striking, the length of time across which ordered recall can be observed increases in a dramatic fashion during this time period; indeed, more than half of 20-month-olds are able to reenact in an ordered fashion portions of to-be-remembered sequences after delays as long as one year (Bauer et al., 2000).

With the rich literature on age-related differences in children's memory for action sequences (Bauer, 2007) as a backdrop, the two primary questions addressed here were: First, what skills *concurrently* predict Elicited Imitation performance, and second, do these linkages vary with age? Few answers to these questions are available in the literature, although intriguing relations have been found between ratings of 20-month-olds' temperament, such as their abilities to sustain interest and focus attention, and corresponding individual differences in Elicited Imitation performance (Bauer, Burch, & Kleinknecht, 2002). Thinking of other skills that might contribute to variation in Elicited Imitation performance, it seems quite probable that children's basic memory capacity and deliberate memory skills – indexed by their performance on the Working Memory for Locations and Hide-and-Seek tasks, respectively – would be linked to their ability to remember previously-modeled action sequences. Indeed, there is a substantial body of work that suggests that limitations in working memory can constrain subsequent cognitive operations and that age-related changes in the capacity of working memory have implications for understanding children's developing abilities in a range of cognitive tasks (Reznick, 2007). Moreover, recent analyses of deliberate and event memory tasks in terms of the same underlying factors that affect the encoding, storage, and retrieval of information (Ornstein, Haden, & Elischberger, 2006) would suggest similar linkages between early strategies and elicited imitation.

It therefore seems likely that performance on the Working Memory for Locations task should predict how well children can do on the Elicited Imitation task because working memory capacity may set fundamental limits on their abilities to represent and reproduce modeled action sequences. It also is possible that performance on a task in which strategies are activated – even the simple naming, pointing, and "peeking" behaviors observed by DeLoache et al. (1985) as objects are hidden – may also be predictive of how well children might do on the Elicited Imitation task because similar processes may underlie performance on each task. Thus, even though the assessment battery was designed to tap aspects of remembering that have been explored in quite different literatures (see Schneider & Bjorklund, 1998), there is good reason to expect across task linkages.

An additional feature of this study is a consideration of children's language as a factor in their abilities to remember modeled action sequences. Language is thought to play a central role in the emergence and development of event memory as it is assessed verbally (see, e.g., Fivush, Haden, & Reese, 2006), but research involving imitation paradigms suggests that the effects of language may not be limited to verbal memory per se (e.g., Bauer & Wewerka, 1995; Hayne & Herbert, 2004; Herbert & Hayne, 2000). Although remembering in the Elicited Imitation task is reflected in the behavioral reproduction of specified actions, the modeling situation typically incorporates what can be viewed as a very helpful verbal narration of the episodes by the examiner. The children thus have available to them at encoding not only the modeled actions, but also a story that goes along with these actions, and children with advanced language skills may be better able to take advantage of the narrative than are those with lower levels of language competency. Indeed, these children may be better able to attend to salient aspects of a modeled sequence, to make sense of the event as it unfolds, and also to incorporate the examiner's narrative into their memory representations.

If language were to affect encoding of the action sequences in this manner – particularly when the children are 24 and 30 months of age – the outcome would be consistent with findings from a variety of studies that suggest that the specific language skills possessed by children at the time an event is experienced can influence the underlying representation and thus contribute to what can be later reported (e.g., Bauer, Kroupina, Schwade, Dropik & Wewerka, 1998; Peterson & Rideout, 1998; Simcock & Hayne, 2002). Research conducted with imitation paradigms in particular suggests that verbal cues provided during the demonstration of an event and at the time of test can improve the nonverbal memory performance of children as young as 18 months old (e.g., Hayne & Herbert, 2004; Herbert & Hayne, 2000). Admittedly, these linkages between children's language and nonverbal memory skills are not always obtained (see, e.g., Bauer et al., 2002; Cheatham & Bauer, 2005, for contrasting results), but it nonetheless is important to examine these potential linkages with the same sample of children at multiple ages. Thus, in this study the children's language abilities were assessed with an examiner-administered standardized instrument at the three target ages (the Preschool Language Scale-3, Zimmerman, Steiner, & Pond, 1992).

In summary, the present study draws on longitudinal data obtained when children were 18, 24, and 30 months of age and makes use of an assessment battery that included three measures of their nonverbal memory and one of their receptive and productive language skills. It addresses questions concerning linkages at each age across nonverbal memory tasks, and possible changes in the patterns of association as children's memory skills develop.

Method

Participants

Across two project sites – Chapel Hill/Durham, NC and Chicago/Evanston, IL – 60 children (30 in North Carolina, 30 in Illinois; 33 female, 27 male) were initially enrolled in the study. The final sample was composed of 57 children reflecting the loss of 3 participants, 2 after the 18-month age point because their families moved, and 1 child after the 24-month age point because the family could not be contacted. On average, the children were 18 months 10 days old (range = 17 months 21 days to 19 months 23 days) at the initial visit at the first assessment, 24 months 18 days old at the second time point (range = 23 months 12 days to 25 months 25 days), and 30 months 21 days old at the third time point (range = 29 months 14 days to 32 months 7 days). All children were from middle to upper-middle class families. The sample was composed of 50 European Americans, 3 Asians, 2 African Americans, and 2 American Indians. At the 18-month age point, 12% of the children's mothers reported having had some college education, whereas 50% indicated that they had received a college degree, and 38% had earned an advanced degree.

Measures and Procedures

At each age, the children were assessed three times in their homes. At 18 months, the first two visits were spaced approximately two weeks apart (*M* delay between Visits 1 and 2 = 14.03 days), whereas at 24 and 30 months, the delay between the first and second visits was approximately three weeks (*M* delay between Visits 1 and 2 = 21.12 days and 22.33 days at 24 and 30 months, respectively). These delay intervals were selected on the basis of a review of the Elicited Imitation literature (e.g., Bauer et al., 2000), so as to achieve delays over which children at the specified ages would evidence recall along with some forgetting. The final visit at each age occurred approximately 1 day after Visit 2 (*M* delay between Visits 2 and 3 = 1.1 days at 18 months, 1.2 days at 24 months, 2.3 days at 30 months). As illustrated in Table 1, the children participated in a range of tasks at each age point, and only those tasks in the battery that are pertinent to this article are described. One of 4 female (2 at each research site) and 2 male (1 at each research site) graduate students administered all of the tasks at a particular age, and often the same individual tested the child at repeated ages.

Elicited Imitation

Task description and procedure: The Elicited Imitation procedure was adapted from the work of Bauer et al. (2000) and involved using a set of props to model individually to each child specific action sequences. The number of steps in the sequence varied as a function of the children's age: three steps at 18 months, five steps at 24 months, and seven steps at 30 months. A complete list of the test sequences used is provided in Table 2. In addition to their length, the sequences also varied by type, such that half of the sequences were arbitrarily ordered (no inherent constraints on the temporal position of actions), and half involved only enabling (each action had to be performed in a temporally invariant order to reach the end state) or a mix of enabling and arbitrary relations across the actions. The order of the presentation of the events was counterbalanced across children at each age point, and the same order was used at the immediate and delayed memory assessments.

As suggested above, at each age, the Elicited Imitation procedure involved an initial exposure and test period that was conducted at Visit 1, and a delayed recall assessment that took place at Visit 2. Prior to introduction of the new events at the 24- and 30-month age points, the children's long-term memory for the events experienced at the previous time point (at 24 months, memory for the 18-month events; at 30 months, memory for the 24-month events; at 36 months, memory for the 30-month events) was also assessed. The Elicited Imitation task began with a familiarization period involving non-target event props and actions that served to establish/reestablish researcher-child rapport and prop-exchange routines (see Bauer et al., 2000, for details). At Visit 1 at each age, familiarization was followed by the presentation of the four target event sequences. For each sequence in turn, the event-related props were first offered to the children to manipulate as they wished (e.g., *"Look at this stuff." "What can you do with this stuff?"*) for a period of time that was dictated by each child's interest (i.e., it ended when the child pushed the props away, or demonstrated some other sort of "off-task" behavior). Each child's spontaneous pre-modeling production of target actions with the props in the target order (e.g., for rattle, putting the block in the cup) formed the basis for determining his or her *baseline* performance.

Next, the specified action sequence was modeled two times in succession. During this modeling, the researcher labeled the sequence (e.g., "*This is how I make a gong*."), and then narrated the actions taken to produce the event. The period of exposure to the events was followed by two consecutive presentations of the props to the children when the researcher encouraged them to imitate that which had been modeled (e.g., "*Can you make a gong just like I did?*"). Children's post-modeling imitation of the events as modeled served as the basis for evaluating their *immediate* performance. After a delay of two (at the 18-month assessment) or three (at 24- and 30-months) weeks, Visit 2 began with a repetition of the familiarization period from Visit 1, followed by a re-presentation of each set of sequence-related props with no instruction or modeling. Children's use of these props to produce the events that they had previously seen modeled was considered for evidence of *delayed* performance.

Scoring and measures: All sessions of this task were videotaped for later analysis. From the videotapes, at baseline and each memory test (immediate, delayed), two dependent variables were scored: (i) the total number of individual target actions produced (maximum = 3, 5 and

7, for each sequence on the three-, five-, and seven-step events, respectively), and (ii) total number of pairs of actions produced in the target order (maximum = 2, 4, and 6 for each sequence on the three-, five, and seven-step events, respectively). For the sequencing measure, only the first occurrence of each target action was considered. For example, if a child produced all three actions in the three-step event in the target order credit would be awarded for three target actions and two correctly ordered pairs of actions (pairing of Action 1 and 2; pairing of Action 2 and 3). However, if the child produced the first and third target actions in that order (i.e., Pair 1 – 3), two points would be credited for the production of target actions, and one point would be credited for production of target sequences. Moreover, if the child produced the actions in the order Action 3-1–2–3, credit was awarded for the production of three target actions, but only one point was given for sequencing (i.e., Pair 1 – 2). Because Action 3 was initially performed prior to Actions 1 and 2, credit was not assigned for the correct ordering of the action when it was produced a second time.

Given that the primary focus of this study was on the prediction of Elicited Imitation performance at each age and not on documenting the ubiquitous age-related increase in skill, the raw scores for each measure were selected for use in the analyses, even though with increases in age the children were presented with events composed of different numbers of steps. Analysis involving direct comparisons across age might require analysis of proportions rather than raw scores. In this regard, however, Bauer (e.g., Bauer et al., 2000) has argued that analyses of Elicited Imitation proportion scores are problematic for the reason that it is not clear, for example, that recalling four out of five actions, for a resulting proportion score of .80, is “better” than recalling two out of three actions, for a proportion score of .67 because in each case the child is only forgetting one action of the sequence. Indeed, the use of proportions could potentially mask developmental changes in memory performance.

There were two coders at the 18- and 24-months time points, and three at the 30-month assessment, and at least one of these individuals participated in the scoring across adjacent time points. Inter-rater reliability was established in such a way that each rater at each time point coded 25% of the baseline, immediate, and delay test sessions. Agreement between pairs of coders average ranged from 84% to 100%, averaging 95%, 95%, and 94% at the 18-, 24-, and 30-month time points, respectively.

At each age, the children’s demonstrations of memory for the target actions and pairs of actions in the Elicited Imitation task were averaged across type (arbitrary, enabling/ mixed) to increase the generalizability of the findings across a range of task difficulty. Performance was summarized according to six different indices: *baseline*, *immediate*, and *delayed* production of component actions and pairs of actions.

Hide-and-Seek

Task description and procedure: Following procedures detailed by DeLoache et al. (1985), each child accompanied the researcher as he or she hid a number of similarly-sized familiar objects (e.g., a Big Bird doll, a ball) in several locations around a room in the child’s house (e.g., under a pillow, behind a curtain). Then, following a delay period, the child was encouraged to search for each object until all were found. The task began with an initial familiarization trial in which only one object was hidden and retrieved immediately by the child. On the test trials that followed, the experimenter introduced two objects at 18 months, three objects at 24 months, and four objects at 30 months, and indicated that the child should remember where these objects were hidden so that later they could be retrieved. Each child watched as the researcher hid all of the objects, and then a timer was set for 2 minutes at the 18-month assessment and 3 minutes at the 24- and 30-month assessments. During the delay interval, the child was engaged in a coloring and/or block stacking activity in the center of the room, and when the timer sounded, the child was urged to find all of the objects. At each age, this procedure was repeated for two trials. Although the same toys were used across trials, they were hidden in different locations in Trial 1 and Trial 2.

Scoring and measures: The analyses of this task focused exclusively on the children's memory performance, expressed as the total number of toys correctly retrieved from their hiding locations across the two trials, regardless of the number of erroneous searches. Therefore, the total maximum scores were 4, 6, and 8, at the 18-, 24-, and 30-month assessment points, respectively. Based on the videotaped records, two research assistants established reliability for 25% of the sample at each age, and there was 100% agreement between the coders for each observation at each time point.

Working Memory for Locations

Task description and procedure: The procedure for this task was modeled after that used extensively in studies of working memory with infants and young children (e.g., Pelphrey & Reznick, 2003; Reznick et al., 1997). On each trial of this task, the child watched the researcher hide a small object under one of several inverted cups, after which his or her view of the cups was obstructed for a delay of a few seconds. Following the delay, the child was encouraged to find the object, and this procedure was repeated over a series of trials of increasing difficulty. At each age, there was first a familiarization period, during which the children were repeatedly presented with two cups at a zero-second delay until they demonstrated comprehension of the task of finding the hidden object. The first test trial involved two cups and a 1-second occlusion. Increases in the level of difficulty of subsequent trials involved first increasing the time the child was asked to wait to uncover the hidden object: two cups at 5-seconds, then two cups at 10-seconds. Next, the number of cups was increased to four, first with a 1-second delay, then with delays of 5- and 10-seconds. In principle, this sequence of delay intervals could have been repeated with six cups and delays up to 15 seconds, but not all children reached this level of difficulty. When the child failed to find a hidden object on a given trial (e.g., two cups and a 10-second delay), that same trial was repeated once, but a second error at the same level of difficulty marked the end of the task.

Scoring and measures: To evaluate the children's working memory capacity, a score was calculated based on the number of correct responses, i.e., the number of times the hidden object was uncovered. For example, a score of 4 indicated that the child had correctly retrieved the toy through four trials before making two consecutive errors, or in other words, had found the object under one of 2 cups after delays of 1, 5, and 10 seconds, and under one of 4 cups after a 1 second delay. At each age point, there were two coders, and at least one of these individuals participated in the scoring across adjacent time points. For each trial, the videotape records were reviewed and the coders scored the child's reaching behaviors as correct (i.e., uncovered the hidden object), incorrect (i.e., did not uncover the location where the object was hidden), or inappropriate (e.g., uncovered two locations at the same time). Reliability was established by two research assistants who coded 25% of the sample at each age, and agreement in making judgments on this task ranged from 80% to 100%, averaging 98%, 99%, and 99% at the 18-, 24-, and 30-month age points, respectively.

Language Skills

Task description and procedure: The Preschool Language Scale – 3 (Zimmerman et al., 1992) was used to assess the children's language skills at each age point. In general, the Preschool Language Scale-3 involves asking the child to point to pictures of named objects, describe pictured actions, and offer definitions of words and actions. The test was administered in the standard format, although to alleviate fatigue the Auditory Comprehension subscale was administered at Visit 2 and the Expressive Communication subscale at Visit 3.

Scoring and measures: Raw scores for each subscale were computed according to the guidelines developed by the test's authors. These were converted to standard scores, and the sum of these standard scores were converted to a Total Language standard score for each child.

Results

Preliminary Analyses

Preliminary analyses revealed that the 18-month baseline performance of the "rattle" event in the Elicited Imitation task was significantly higher than for the other three events that were administered at that age point ($Fs \geq 32.96$, $ps < .01$), suggesting that the children could essentially perform the activity even before it was modeled by the researcher. This being the case, the rattle event was excluded and the reported results are based on averages across the three remaining events at the 18-month assessment point, whereas at the two older ages the averages were computed across four events. The same procedure used to assess delayed performance after 2–3 weeks was used 6-months after modeling, but consistent with prior work (Bauer et al., 2000), preliminary analyses confirmed that Elicited Imitation performance did not differ between the 2–3 week and 6-month delays, although there was more missing data at the 6-month delay. Given the stability of performance over the short and long delay intervals, to avoid losing data, 6-month delayed scores were substituted for corresponding 2–3 week delay scores for the 2, 1, and 3 children, respectively, who had missing 2–3 week delayed Elicited Imitation performance data at the 18-, 24-, and 30-month age points.

Descriptive Analysis

The means and standard deviations of the four measures of Elicited Imitation performance are presented in Table 3. At each age, to determine if the children learned the event sequences, their immediate and delayed imitation performance was compared with their baseline levels of performance. Immediate performance was also compared with delayed performance to gauge retention of information over time. To avoid redundancy with the regression analyses reported below, differences across age were not tested in these analyses. Therefore, separate oneway analyses of variance (ANOVAs) with Bonferroni adjustment for multiple comparisons were conducted at 18, 24 and 30 months, to test for effects of assessment (baseline, immediate, delayed) on actions and pairs performance. These analyses yielded significant effects of assessment at each age, for both actions ($Fs \geq 186.19$, $ps < .001$, $\eta^2s \geq .68$) and pairs ($Fs \geq 77.53$, $ps < .001$, $\eta^2s \geq .47$). As is illustrated in Table 3, at every age, the comparison of immediate to baseline performance indicated that the children had learned both the individual target actions and pairs of actions. Delayed performance was also better than baseline, although fewer actions and pairs were produced following the delay of weeks than immediately after modeling (all $ps < .001$).

To characterize further the children's performance, the descriptive statistics for language skill as assessed via the Preschool Language Scale-3, deliberate memory as measured in the Hide-and-Seek task, and working memory as indexed in the Working Memory for Locations task are displayed in Table 4. The mean standard scores on the language measure suggest that the children were of average to above-average linguistic ability relative to the PLS norming sample. A one-way ANOVA testing differences in total PLS standard scores by age was statistically significant, $F(2, 162) = 18.09$, $p < .001$, $\eta^2 = .18$, and follow up tests indicated that the children's 24 and 30 month language scores were significantly different from those at 18 months; 24 and 30 month scores were not different from each other. The Hide-and-Seek measures indicate that the children were able to retrieve 2.10 hidden toys (of 4) at the 18-month assessment and 5.18 toys (of 8) by the time they were 30 months old. Moreover, on the Working Memory for Locations task, the children they could continue with the task through a mean of 3.05 trials (corresponding to finding an object underneath of one of two cups after delays of 1, 5 and 10 seconds) when they were 18 months of age, and 6.02 trials (finding an object located under one of four cups at a 10-second delay) by the time they were 30 months old. One-way ANOVAs performed on these memory measures indicated significant improvements in performance at each age *(Fs* =70.12 and 20.79, η^2 = .45 and .19, for performance of the Hide-and-Seek and Working Memory for Locations task, respectively, *ps* < .01).

Correlational Analyses

A series of correlational analyses was conducted to examine the (a) stability of the children's performance over time, and (b) concurrent relations among the language and memory measures at each time point. Turning first to the issue of stability of performance, correlations were computed for performance on each measure between 18 and 24 months, 18 and 30 months, and 24 and 30 months. As illustrated in Table 5, although children's early and later language skills were interrelated, in general, for the memory measures, little stability in the children's performance was found across age. In particular, looking at the Elicited Imitation measures, the children's performance of actions immediately after modeling at 18 months was modestly associated with immediate performance of actions at the later two time points. For the immediate pairs measure, fairly low associations were found in children's performance between 18 and 24 months, and 24 and 30 months. For the delay measures, stability was found in performance of actions between 18 and 24 months, 18 and 30 months, and 24 and 30 months, but only in performance of pairs of actions between 24 and 30 months. With regard to deliberate memory and working memory, the only across-time correlation found was a small positive association for children's performance on the deliberate memory task between the 18- and 24-month time points.

In the concurrent analyses of interrelations among the memory and language measures, deliberate memory was not significantly correlated with working memory (*rs* = .11 – .20, *ps* > .13), or with language skills (*rs* = .08 – .21, *ps* > .13) at any age. Working memory was linked to language skill at 24 months (r = .29, p < .05), but not at 18 or 30 months (*rs* = .06 and .11, respectively; *ps* > .13). The question of whether the children's Elicited Imitation performance at each age was concurrently related to their language, deliberate memory, and working memory skills was addressed in the main analyses that are summarized below.

Concurrent Prediction of Elicited Imitation Performance at Each Age

To examine the extent to which the language and memory measures were linked concurrently to the children's performance on the Elicited Imitation task, repeated measures analyses using a general linear mixed model approach were conducted on the 18, 24, and 30 month imitation indexes twice for each retention interval (i.e., immediate, delay). In each analysis, the repeated measures were accounted for through an autocorrelation structure that allowed assessments closer in time to be more highly correlated. The predictors included the repeated measures of language, working memory, and deliberate memory, also collected at 18, 24 and 30 months of age, as time-varying covariates.

Several models were fit to predict the data for each of four indices of Elicited Imitation performance: immediate and delayed production of component actions and pairs of actions. The models predicting delay performance were run twice, once without controlling for the children's immediate performance, and a second time with immediate performance as a covariate. The first model for the prediction of each index included gender and age and tested the extent to which each index varied over time and whether these patterns were different for boys and girls; site was also included in the first model to examine the comparability of findings across our two test sites. The second model added language skills prior to the deliberate memory and working memory measures because, based on previous research, it could be expected that concurrent linguistic skills would be associated with the children's Elicited Imitation performance. The third step involved two separate models, 3A and 3B for each index of Elicited Imitation performance. Model 3A built upon the second model by adding concurrent deliberate memory performance and its interaction with age to determine the extent to which deliberate memory predicted Elicited Imitation performance and whether the prediction varied as a function of age. In a parallel fashion, Model 3B extended the second model by adding the time-varying measures of working memory, instead of those of deliberate memory performance. In the absence of a priori evidence concerning the relative importance of deliberate and working memory skills as predictors of Elicited Imitation performance, these two separate but parallel models were established to allow for independent assessments of the contribution of each of these two predictors, as opposed to adding one before the other or using a single model including both measures simultaneously.

In the second and third steps (both 3A and 3B) of these analyses, the main effect of each predictor (i.e., language, deliberate memory, working memory) describes an association with an index of Elicited Imitation performance, and in the absence of an interaction with age, suggests that a similar concurrent association between the predictor and Elicited Imitation outcome exists at all ages. The Predictor × Age interactions describe associations with Elicited Imitation performance that change over time; it should be noted that at each step, non-significant interactions were dropped from the model. The results of these analyses are summarized in Table 6. In addition to the *F* values and Betas displayed in Table 6, effect sizes (*d* values) were calculated to describe the magnitude of the associations among the Elicited Imitation and predictor variables. Each effect size was computed as the regression coefficient multiplied by the standard deviation of the predictor variable (i.e., language, working memory, deliberate memory) divided by the standard deviation of the Elicited Imitation performance measure. For these effect sizes, *d* values below .20 are traditionally viewed as “modest,” *ds* between .20 and 60 are taken to be “moderate,” and *ds* above .60 are seen as “large” (Cohen, 1988).

The upper section of the table displays the results for the initial step or base model that characterizes changes in Elicited Imitation performance as a function of age or time of assessment, and includes research site and gender as covariates, along with the Gender × Age interaction that was computed to examine possible differences in patterns of change over time for boys and girls. The middle portion of Table 6 presents the second step and illustrates the effects of adding language and the Age × Language interaction to the base model, and the bottom panel shows the two third step models that evaluate the additional impact of the deliberate and working memory measures and their interactions with age as predictors of the children’s production of modeled action sequences. The test statistics are listed for each main effect and for the interactions with age. In addition, the adjusted means and their standard errors are shown for the categorical predictor, age, and the regression coefficients, with the standard errors being displayed for each continuous predictor. The results for each part of the analyses are presented below.

Base Model—Inspection of the base model results presented in the top portion of Table 6 suggests that all four measures of the children’s Elicited Imitation performance were comparable at the two research sites. There were, however, main effects of gender and age. Specifically, the tests involving gender indicate that girls were outperforming boys on all measures of Elicited Imitation performance. Comparison of the analyses of delayed performance without and with immediate performance as a covariate suggests that the effects of gender at all ages were primarily due to the higher production of actions and pairs at the immediate assessment by the girls, in contrast to the boys. Girls also produced more actions than the boys at the delayed assessment at the 30-month age point.

The main effects of age reflect differences in the number of actions and pairs of actions produced at each age point, with the adjusted mean scores in Table 6 illustrating higher levels of initial and delayed performance at the 24- and 30-month time points relative to that observed at the 18-month assessment. When considering the main effects of age for Elicited Imitation performance it is important to keep in mind that the children were performing events with different numbers of steps at each age.

Language, Deliberate Memory, and Working Memory—To address the question of the extent to which the children's Elicited Imitation performance is associated with their language abilities, skills for deliberate remembering, and working memory capacity, as indicated above, one repeated measures analysis model was carried out in which language was added to the base model (see Step 2 in Table 6). Then, two additional parallel conditional models were tested, one adding deliberate memory and the other, working memory, once the effects of language had been taken into account (see Steps 3A and 3B in Table 6). Given that deliberate memory and working memory skills, as assessed, were not interrelated, this approach was taken to test how each skill might contribute independently to children's abilities to reproduce modeled event sequences.

Language—As illustrated in the second section of Table 6, the children's total language standard score from the Preschool Language Scale-3, was associated significantly with their immediate production of component actions and pairs of actions in the Elicited Imitation task, and these associations, although modest, become stronger with age. Specifically, the Language × Age interactions with immediate performance indicate that language skills emerge as a predictor of the production of pairs of actions at 24 months of age and individual components as well as pairs at 30 months. For example, at 30 months of age the children increased their immediate production of actions by .042 for every one point increase in their Preschool Language Scale-3 total score. For the association between language and immediate performance of actions, the effect size ranged from ranged from d = .16 at 18 months, to d = .34 at 24 months, to d = .50 at 30 months, whereas for the relation between language and the immediate production of pairs of actions ranged from d = .10 at 18 months, to d = .28 at 24 months, to d = .45 at 30 months.

In contrast to immediate Elicited Imitation performance, assessment of the children's performance following the delay illustrated in the middle and right-hand sets of columns in Table 6, indicate main effects of language in the absence of Language × Age interactions. These outcomes suggest that the children's language skills were positively associated with delayed performance of both the actions and pairs of actions, at each age. The effect sizes associated with these main effects were d = .24 for the components measure, and d = .24 for the pairs measure without controlling for immediate performance. It is of note that when the children's immediate performance was included as a covariate, the main effects of language on delayed performance were reduced in magnitude, still statistically significant for the production of actions and reflecting a statistical trend for the production of pairs. These results suggest that beyond both the children's immediate performance and the association between immediate performance and their language skills, language abilities uniquely, albeit modestly, contribute to delayed Elicited Imitation performance at all three ages.

Memory Skills—As indicated in the third section of the table (step 3A), over and above the effects of language, there is evidence for the significant unique contributions of deliberate memory skill to the prediction of children's immediate Elicited Imitation performance for both the components and pairs measures. Effect sizes of d = .19 and d = .24 were obtained for the immediate actions and sequencing measures, respectively. Thus, the children's abilities to search and retrieve toys in the Hide-and-Seek task were associated with their immediate post-modeling production of the actions and ordering of the actions in the Elicited Imitation task.

Moreover, the failure to obtain Deliberate Memory × Age interactions suggests that these associations did not vary significantly with age. Comparison of the analysis involving delayed performance without and with immediate performance controlled further suggests that deliberate memory skill was primarily impacting the children's immediate performance. More specifically, although without controlling for immediate performance, performance on the deliberate memory task was significant associated with delayed production of components, and tended to be associated with the delayed production of pairs, with effect sizes of d = 16 and .12, respectively, these results were reduced to nonsignificant when immediate performance was included as a covariate.

In addition to the children's language skills, their working memory capacity as assessed on the Working Memory for Locations task was also found to be associated positively with immediate and delayed performance of both actions and correct ordering of pairs of actions on the Elicited Imitation task. The effect sizes associated with these linkages were d = .13 and .13 for immediate performance, and d = .20 and .19 for the delayed performance of actions and pairs, respectively. Further, a significant Working Memory × Age interaction for the delayed production of pairs of actions was obtained once immediate performance was controlled. This interaction suggests that at 30 months, the higher the children's working memory skills the higher their performance at sequencing of target actions after a 3-week delay. For the association between working memory and the delayed production of pairs the effect sizes ranged from d = .21 at 18 months, to d = −.01 at 24 months, to d = .32 at 30 months. More specifically, at 30 months of age for every increase of one point in working memory capacity, there was a corresponding increase in performance of .091 action pairs.

Discussion

This investigation was motivated by two salient gaps in the literature concerning children's early memory skills. First, despite innovative research illustrating the impressive mnemonic competencies that begin in infancy and continue through toddlerhood, little is known about how different measures of young children's explicit memory may be interrelated, particularly those tapping nonverbal aspects of remembering. Second, because few studies have tracked the same children over time, there is a paucity of information concerning the changing patterns of association across tasks that may be observed with development. Capitalizing on the longitudinal design employed in the present study, it was possible to establish at each of three age points the extent to which working memory, deliberate memory, and language predict the children's Elicited Imitation performance, as well as whether the patterns of association are different across the different ages.

To a considerable extent, the average levels of performance that were found on each of the memory tasks replicate prior work in which one or another of these nonverbal memory tasks has been employed with cross-sectional samples. Indeed, with few exceptions, the mean levels of memory demonstrated on each task were very similar to values that have been reported in previous research for children of similar ages. Consider, for example, that in a study in which children were exposed to three-step action sequences six times across three exposure sessions, Bauer et al. (2000) found that 16-month-olds' productions of actions and pairs of actions ranged from 2.59 to 2.94, and 1.11 to 1.44, respectively. In comparison, even though the children in the present study were slightly older and received only two demonstrations of each three-step action sequence, their immediate performance was just slightly lower than that reported by Bauer et al. (2000), with an average of 2.34 component actions and .87 action pairs produced at 18-months. It is also worth noting that the advantage for girls found in this study is consistent with the only other report in the literature to find effects of gender on this task with children aged two and older (Bauer, Hertsgaard, Dropik, & Daly, 1998).

Likewise, whereas DeLoache et al. (1985, Experiment 4) demonstrated that 21- to 25-month-old children retrieved approximately 53% of the toys that were hidden in a laboratory setting, the average retrievals for the present sample at 24 months was a very comparable 60%, or 3.64 toys retrieved from locations around the family’s home. Although it is difficult to find working memory data in the literature that map neatly on to the task parameters employed here, the general sense is one of comparability. For example, the performance of the children in this is just shy of that reported by Reznick et al. (1997) in a longitudinal twin study. To illustrate, Reznick et al. observed that 20-month-olds could retrieve a toy that had been hidden beneath one of six cups after a delay of one second, whereas at 18 months of age, the children in the present sample could retrieve a toy that was hidden under one out of four cups after a 10-second delay.

Despite the focus in this investigation on nonverbal assessment of young children’s remembering, the first step in the analyses was to consider how children’s language proficiency at the time of the experience of the Elicited Imitation events might be associated with their performance. Admittedly, as in studies of categorization and theory of mind that have focused on the relations between children’s language and other areas of cognitive developments (see e.g., Astington & Baird, 2005, on theory of mind; Rakison & Oakes, 2003, on categorization), the extant literature on children’s memory is mixed, with reports of both linkages between children’s language skills at encoding and subsequent remembering and of failures to find these associations. Interestingly, these inconsistent findings can even be observed within the same laboratory with the same assessment tool, the MacArthur Communicative Development Inventories (cf., Bauer et al., 1998; Bauer et al., 2002; Cheatham & Bauer, 2005). In the present investigation, it was observed that children’s language skills were associated with performance immediately after modeling for both the actions and pairs measures of memory in the Elicited Imitation task. Thus, to a considerable extent, these results are similar to and extend those obtained by Bauer et al. (1998) and Bauer and Wewerka (1995), in which the productive vocabulary of 16- and 20-months-olds was related, albeit modestly, to memories expressed nonverbally at an immediate assessment. Accordingly, the present findings suggest the tentative conclusion that at least by the age of 2, the language available to children as an event unfolds is an important determinant of what gets into memory (see also Boland, Haden, & Ornstein, 2003).

Somewhat in contrast to the Bauer et al. (1998) and Bauer and Wewerka (1995) studies, however, the language skills of the children in this study were related to nonverbal measures of performance after a 2- to 3-week delay. Indeed, that this effect was maintained even after controlling for immediate Elicited Imitation performance suggests that linguistic skills can exert unique effects on children’s remembering (see also Hayne & Herbert, 2004). Previous studies document substantial linkages between children’s linguistic abilities after an event has been experienced and subsequent *verbal* indications of long-term retention and forgetting (see Bauer, 2006; and Fivush et al., 2006), and these results with nonverbal production are in accord with these findings. However, it must be emphasized that the current sample had generally high standardized language scores, and future work is needed to address what linkages might be found with a more linguistically diverse group. What is more, to say that there is a relation between language and children’s – verbal or nonverbal – event memory is to oversimplify, and the critical question for future research is *why* language matters for children’s developing skills for remembering.

Over and above the associations with language, measures of the children’s immediate production of modeled sequences were associated with their deliberate memory performance, and these linkages were observed at all three ages. Importantly, however, the observation that the associations between the Elicited Imitation performance and deliberate memory skill as assessed on the Hide-and-Seek task were lost once immediate performance was controlled suggests that the linkage between Elicited Imitation performance and deliberate memory skill is principally at the level of learning the target actions and sequences of actions. This finding may reflect the operation of similar factors that impact the children's encoding and the reproduction of an adult's actions after a short period of time, regardless of whether they are told explicitly to remember the researcher's activity of hiding objects, as in the Hide-and-Seek task, or they are engaged in a game in which the rule is to "make an X" just in the way it was modeled by the researcher, as in the Elicited Imitation task. For example, successful performance on each task may involve the children's abilities in focusing attention on the researcher's actions at the time of initial exposure, and also, perhaps, a sensitivity to the need to do something in an effort to remember.

These across-task relations on nonverbal event and deliberate memory tasks are particularly interesting, when contrasted with the mixed findings regarding preschoolers' and older children's performance on verbally-based tasks. For example, although Haden, Ornstein, Eckerman and Didow (2001) reported relatively strong associations between children's event recall at 30 months and their deliberate memory performance as much as a year later, whereas Lange and Carroll (2003) obtained negative across-task correlations. Although these differences could stem from the substantially different tasks and methodologies used to assess children's event and deliberate memory skills and the longitudinal versus cross-sectional analytic strategies employed in these two studies, they may also reflect the dramatic transitions in cognition that are observed in the preschool period. Consistent with this interpretation, studies involving school aged children suggest few linkages across verbal memory tasks (Knopf, Körkel, Schneider, & Weinert, 1988; Weinert & Schneider, 1995) and even dissociations among different measures of children's deliberate memory skills. It seems clear that further research is needed to understand the extent to which children who have better memories for events also prove to be more skilled - both concurrently and longitudinally – at both nonverbal and verbally-based deliberate memory tasks.

In addition to the contributions of language skills to the concurrent Elicited Imitation performance, the children's working memory capacity was also positively associated with immediate performance of modeled actions, and with the delayed production of both actions and action pairs. Moreover, with immediate performance controlled, it was apparent that by 30 months of age, the better the children's working memory skills the better their delayed production of sequences of pairs of actions. These findings are consistent with the view (Ornstein et al., 2006; Reznick, 2007) that the capacity of working memory sets limits on the amount of information that can be encoded and subsequently retrieved. Indeed, the linkage between performance on the Working Memory for Locations task and delayed Elicited Imitation performance may reflect the quality of the representation that was established initially. To be sure, within the context of the present longitudinal investigation, these data set the stage for further exploration of the ways in which basic memory capacity interacts with a range of child and contextual variables to influence the development of a broad set of skills for remembering.

The present study is unique in its demonstration of concurrent relations among measures of children's language, working memory, deliberate memory, and event memory at multiple age points as these skills emerge and become consolidated. Nevertheless, additional work is clearly necessary to replicate and extend these findings with longitudinal research that includes assessments of children's performance on multiple tasks. It is particularly important to specify key underlying mechanisms for across-task associations and to explore the extent to which, for example, there may be similar processes at play as children encode events that they are experiencing and "study" items that have been hidden (Ornstein et al., 2006). In addition, given the broad longitudinal investigation in which this study is embedded, the present data can offer a foundation for future research addressing the prediction of children's later skill in verbally-based assessments of remembering, both those involving the incidental recall of personally-experienced events and those calling for deliberate preparation for subsequent assessments of memory. Although it is difficult to talk about the prediction of skills that are undergoing rapid development, it seems likely that composite measures of children's skill in the 18- to 30-month period will be linked reliably to performance in the preschool and early school years.

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Table 1

Timing of tasks administered to the children at 18, 24 and 30 months

Visit	18-months	24-months	30-months
1		Elicited Imitation – Performance of 18-month events after Long-term Delay[a]	Elicited Imitation – Performance of 24-month events after Long-term Delay[a]
	Elicited Imitation - Modeling and Immediate Performance[a]	Elicited Imitation - Modeling and Immediate Performance (new events)[a]	Elicited Imitation - Modeling and Immediate Performance (new events)[a]
	Hide-and-Seek[a]	Hide-and-Seek[a]	Hide-and-Seek[a]
	Mother-Child Reminiscing	Mother-Child Reminiscing	Mother-Child Reminiscing
	Working Memory for Locations[a]	Working Memory for Locations[a]	
2	Elicited Imitation – Performance after Delay[a]	Elicited Imitation – Performance after Delay[a]	Elicited Imitation- Performance after Delay[a]
	Preschool Language Scale – 3 Receptive[a]	Preschool Language Scale – 3 Receptive[a]	Preschool Language Scale – 3 Receptive[a]
	Story Construction	Story Construction	Story Construction
3	Working Memory Hide-and-Seek	Working Memory Hide-and-Seek	Working Memory Hide-and-Seek
	Preschool Language Scale-3 – Expressive[a]	Preschool Language Scale-3 – Expressive[a]	Preschool Language Scale-3 – Expressive[a]
			Working Memory for Locations[a]
	Mother-Child Free-Play	Mother-Child Free-Play	Mother-Child Free-Play

Note. Tasks were administered within a session in the order they are listed in the table.

[a]Tasks included in this report.

Table 2

Elicited Imitation Event Sequences Used

Event (Type)	Description of Action Sequences
	Three-step action sequences performed at 18 months
Rattle (Enabling)	Researcher modeled putting the block in one half of a barrel, putting the two halves of the barrel together, and shaking the barrel to make a noise.
Gong (Enabling)	Researcher modeled putting a crossbar atop the two posts, hanging a metal plate on the crossbar, and hitting the plate with a plastic mallet.
Bunny (Arbitrary)	Researcher modeled putting on the bunny’s ears, putting on the bunny’s eyes, and “feeding” the bunny a carrot (holding it to the bunny’s mouth and saying “num, num, num”).
Party Hat (Arbitrary)	Researcher modeled putting cloth band around the bottom on the cone hat, putting a pom-pom on the top of the cone, and putting a sticker on the front of the cone.
	Five-step action sequences performed at 24 months
Picnic (Mixed)	Researcher modeled spreading out a small fabric square blanket, putting a bear on the blanket, putting a hat on the bear, cutting a birthday cake, and putting a piece of cake in a bowl.
Train (Mixed)	Researcher modeled putting a train track together, putting the train on the track, hanging a bell on the train, moving a road block, and driving the train under a bridge.
Tugboat (Arbitrary)	Researcher modeled putting the top on a tugboat, putting a life ring on the side of the tugboat, hooking up a raft to the tugboat, pulling in the anchor, and putting a light on top of the tugboat.
Garden (Arbitrary)	Researcher modeled raking a garden, watering the garden, putting a flower in a hole, attaching a garden gate, and hanging a sun on a post.
	Seven-step action sequences performed at 30 months
Trucks (Mixed)	Researcher modeled putting a seat in the truck, putting the driver in the seat, washing the tire, putting the screwdriver together, fixing the truck, loading the truck, and dumping it.
Snow (Mixed)	Researcher modeled pouring snowballs, making it snow, building a snowman, making a mountain, taking the bear skiing, pouring cocoa in the cup, and stirring the hot chocolate.
Birthday Art (Arbitrary)	Researcher modeled decorating a piece of paper, rolling a paintbrush over the paper, putting on the decorative clip, putting on the frame, putting a bow on the frame, stamping the paper, and putting on a cookie sticker.
School (Arbitrary)	Researcher modeled driving a bus to school, hanging up the flag, sitting a child at the desk, putting up the chalkboard, playing on the see-saw, giving the teacher an apple, and erasing the chalkboard.

Table 3

Means (and Standard Deviations) for Children's Elicited Imitation Performance over Time

	Age Point		
Elicited Imitation Performance	**18 Months**	**24 Months**	**30 Months**
Baseline			
Actions	0.42 (0.38)	0.70 (0.47)	1.37 (0.65)
Pairs	0.02 (0.09)	0.11 (0.21)	0.30 (0.27)
Immediate			
Actions	2.34 (0.58)	4.34 (0.63)	5.75 (1.30)
Pairs	0.87 (0.47)	2.10 (0.58)	3.18 (0.99)
Delay			
Actions	1.77 (0.66)	3.25 (0.81)	4.56 (1.19)
Pairs	0.51 (0.44)	1.31 (0.58)	2.25 (0.81)

Note. Performance is based on three-, five- and seven-step actions sequences performed at 18, 24, and 30 months, respectively.

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Table 4

Means (and Standard Deviations) for Language, Deliberate Memory and Working Memory Measures

	Age Point		
Measure	**18 Months**	**24 Months**	**30 Months**
Language	100.45 (15.36)	112.88 (16.34)	118.17 (15.38)
Deliberate Memory	2.10 (1.12)	3.64 (1.49)	5.18 (1.57)
Working Memory	3.05 (1.83)	4.59 (2.70)	6.02 (2.85)

Table 5

Across Time Correlations for the Memory and Language Measures

	Age Point		
Measure	**18–24 Months**	**18–30 Months**	**24–30 Months**
Elicited Imitation			
Immediate Actions	.35**	.29*	.23
Immediate Pairs	.26*	.19	.26*
Delayed Actions	.38**	.28*	43***
Delayed Pairs	.07	.13	.28*
Language	.54***	.46**	.69***
Deliberate Memory	.27*	.08	.21
Working Memory	.19	.25	.24

* $p < .05$,

** $p < .01$,

*** $p < .001$.

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Table 6

Predicting Elicited Imitation Performance from Language, Deliberate Memory and Working Memory Skill

		Elicited Imitation Performance					
		Immediate		Delay		Delay (Covarying Immediate Performance)	
Predictors		**Actions**	**Pairs**	**Actions**	**Pairs**	**Actions**	**Pairs**
Step 1 BASE MODEL							
Site	*F*	0.02	0.00	1.27	0.08	2.74	0.03
Gender	*F*	4.86^{*}	4.77^{*}	5.00^{*}	4.92^{*}	2.41	1.67
Age	*F*	226.21^{***}	158.08^{***}	163.76^{***}	116.78^{***}	0.42	1.83
18 months	$M^{1}(SE)$	2.31 (0.12)	0.86 (0.09)	1.75 (0.12)	0.50 (0.08)	2.84 (0.29)	0.92 (0.18)
24 months	$M^{1}(SE)$	4.32 (0.12)	2.09 (0.09)	3.24 (0.12)	1.31 (0.08)	3.09 (0.09)	1.28 (0.07)
30 months	$M^{1}(SE)$	5.74 (0.12)	3.16 (0.10)	4.52 (0.12)	2.22 (0.08)	3.42 (0.14)	1.67 (0.01
Gender × Age	*F*	0.22	0.71	1.44	2.20	3.19^{*}	1.70
Gender @ 18	*B(SE)*					.015 (.182)	
Gender @ 24	*B(SE)*					−.022 (.174)	
Gender @ 30	*B(SE)*				.	515^{**} (.172)	
Immediate (Covariate)	*F*					83.81^{***}	52.37^{***}
Immediate (Covariate) × Age	*F*					0.32	0.81
Step 2 LANGUAGE							
Language	*F*	17.02^{**}	$13\ 77^{***}$.	16.53^{***}	14.35^{***}	4.42^{*}	3.65^{+}
Language	*B(SE)*	$.020^{***}$ (.005)	015^{***} (.004)	$.020^{***}$ (.005)	$.013^{***}$ (.003)	$.008^{*}$ (.004)	$.006^{+}$ (.033)
Language × Age	*F*	6.00^{**}	4.15^{*}	1.18	0.45	0.92	0.31
Language @ 18	*B(SE)*	.006 (.007)	.003 (.006)				
Language @ 24	*B(SE)*	.011 (.007)	$.012^{*}$ (.006)				
Language @ 30	*B(SE)*	$.042^{***}$ (.008)	$.029^{***}$ (.070)				
Step 3A DELIBERATE MEMORY							
Deliberate Memory	*F*	11.59^{**}	14.01^{***}	6.37^{*}	2.82^{+}	0.57	0.01

		Elicited Imitation Performance											
		Immediate				Delay				Delay (Covarying Immediate Performance)			
Predictors		Actions		Pairs		Actions		Pairs		Actions		Pairs	
Deliberate Memory	*B(SE)*	$.166^{***}$	(.048)	$.149^{***}$	(.040)	$.122^{*}$	(.048)	$.060^{+}$	(.035)	.030	(.040)	003	(.033)
Deliberate Memory × Age	*F*	1.33		1.81		0.79		0.78		0.02		0.20	
Step 3B WORKING MEMORY													
Working Memory	*F*	8.18^{**}		5.31^{*}		15.35^{***}		10.62^{**}		11.42^{**}		6.23^{*}	
Working Memory	*B(SE)*	$.081^{**}$	(.029)	$.055^{*}$	(.024)	$.108^{***}$	(.027)	$.065^{**}$	(.020)	$.078^{**}$	(.023)	$.045^{*}$	(.018)
Working Memory × Age	*F*	1.39		1.01		2.41^{+}		1.93		2.82^{+}		3.76^{*}	
Working Memory @ 18	*B(SE)*					$.194^{**}$	(.058)			$.156^{**}$	(.052)	.047	(.040)
Working Memory @ 24	*B(SE)*					.051	(.038)			.019	(.031)	−.003	(.025)
Working Memory @ 30	*B(SE)*					$.079^{*}$	(.037)			$.060^{*}$	(.029)	$.091^{***}$	(.024)

[1] Means are adjusted for the covariates: site and gender.

$^{+}p < .10$,

$^{*}p < .05$,

$^{**}p < .01$,

$^{***}p < .001$