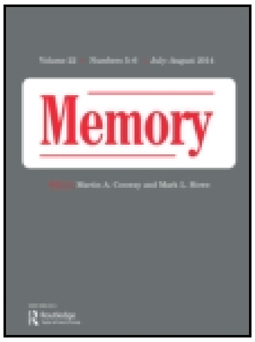

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Language facilitates event memory in early childhood: Child comprehension, adult-provided linguistic support and delayed recall at 16 months

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Adult-provided supportive language facilitates memory for the past in preverbal and verbal children. Work conducted with 18-month-olds indicates that children benefit from supportive adult language when tested after a 4-week delay but not when tested immediately after sequence demonstration; moreover, findings reveal that supportive language provided only at test may be more facilitative of recall after a delay relative to supportive language provided only at encoding. In the present study, we examined whether child language comprehension abilities moderated the extent to which preverbal children benefitted from supportive language provided at encoding and test. The findings indicated that child language comprehension and supportive language provided at encoding were unassociated with performance at baseline or immediate imitation; however, the moderating effect of child language comprehension on adult-provided supportive language at encoding and test was observed after a 1-week delay. Correlations revealed continuous associations between general comprehension scores and recall performance after the 1-week delay on sequences presented in the most supportive condition at encoding. Taken together, the presented findings reveal that the complex interplay between language and cognition is established in early childhood, with foundational relations emerging before children are capable of verbally reporting on the past.

Keywords: Language; Comprehension; Memory; Infant; Child.

Adults are commonly unable to recall memories from their first years of life, a phenomenon known as infantile amnesia. Numerous arguments have been proposed to explain this relative lack of memories from infancy and early childhood, including the possibility that memories from infancy were not reported by adults because infants were unable to mentally represent the past (i.e., no memories were encoded, and as such, none were retained; Piaget, 1952) as well as the possibility that experiences during infancy and early childhood were so traumatic that they

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were repressed, never to be accessed again (i.e., that memories were encoded but remained inaccessible to conscious recollection; Freud, 1905/1953, 1916–1917/1963). More recent hypotheses surrounding the occurrence of infantile amnesia focus on potential changes in memory format over time (i.e., that the formation of memories early in life may be qualitatively distinct from those formed later in life, ultimately making the former inaccessible with age) and changes in the cues required to support recall (i.e., that early memories may be predominantly triggered by non-verbal cues, whereas language is primarily responsible for cueing event memory later in life; see Howe & Courage, 1993). Indeed, findings suggest that episodic memories encoded in non-verbal formats are accessible to language at later ages (Bauer, Kroupina, Schwade, Dropik, & Wewerka, 1998; Bauer, Wenner, & Kroupina, 2002; Cheatham & Bauer, 2005; although see Simcock & Hayne, 2002). Preverbal children are also able to use adult-provided supportive language to structure their event memory, such that more supportive adult language use is associated with better behavioural recall after a 4-week delay relative to when less supportive language is provided (Hayne & Herbert, 2004). In the present research, we examine whether child language comprehension abilities moderate the extent to which 16-month-old children benefit from supportive adult-provided language at encoding and test in a within-subjects design.

One of the challenges in establishing language-recall relations in preverbal infants and children is methodological, as these samples cannot report on the past through verbal report. As such, researchers developed the elicited imitation procedure to behaviorally assess recall memory and related abilities. In one version of this procedure, children are presented with novel stimuli that can be used to complete a sequence of actions that results in an end- or goal-state that infants tend to find enjoyable. After a pre-demonstration baseline period, a researcher models the sequence of actions with narration. Imitation is then permitted immediately as an index of encoding, after a delay as an index of delayed recall, or both. The data are then coded to determine whether children produce the target actions demonstrated by the researcher and whether they are performed in the same temporal order (see Bauer, DeBoer, & Lukowski, 2007). Although there have been no direct relations between elicited imitation performance in infancy and later autobiographical memory to our knowledge, multiple arguments support the notion that episodic memories—of which autobiographical memories are a subset—are assessed through the use of the elicited imitation procedure (see Bauer in 1995, 1996, 1997, 2002, 2007, 2008).

Researchers have modified the language children are presented within the context of elicited imitation testing so as to determine whether adult-provided language facilitates recall memory and related abilities in preverbal infants and children. In one study (Bauer, Hertsgaard, & Wewerka, 1995), a researcher demonstrated three-step event sequences to 15-month-old children along with Full Narration (the name of the sequence and narration of the individual actions as they were completed). Children were permitted the opportunity to imitate the demonstrated actions immediately after sequence presentation and delayed recall was tested 1 week later. At delayed recall, children in the Verbal Reminder group were presented with the sequence materials and the name of the event sequence, whereas children in the No Verbal Reminder group were presented with the sequence materials and no verbal prompts. The results indicated that children in both groups showed evidence of recall after the 1-week delay, and delayed recall performance did not differ significantly by group. However, analyses of forgetting (comparisons of performance at immediate imitation relative to delayed recall) revealed that forgetting was apparent for children in the No Verbal Reminder group but not for those in the Verbal Reminder group. These findings suggest that adult-provided supportive language at test serves as an effective retrieval cue when supportive language was also provided at encoding.

Other research has confirmed and extended these findings. In a series of two experiments, Hayne and Herbert (2004) examined causal links between adult-provided language at encoding and test over the short-term (immediate imitation; Experiment 2A) and over a 4-week delay (Experiment 1). Eighteen-month-old children were presented with three-step event sequences along wither either Full Narration or Empty Narration. Children tested in the Full Narration group witnessed the demonstration of events that were modeled along with the name of the sequence and narration of the individual action phrases, whereas children tested in the Empty Narration group witnessed the demonstration of the events in the absence of sequence-specific language; children were instead provided with language that did not provide any meaningful event-related information ("Let's have a look at this. Then we have this bit. That was pretty neat, wasn't it?" p. 131). At the test, children in the Full Narration group were provided with the name of the event sequence; children in the Empty Narration group were provided with a general verbal prompt ("What can we do with these things?" p. 131). The findings indicated that children in the Full Narration and Empty Narration groups performed better than a control group who did not witness the demonstration of the actions at both immediate imitation (Experiment 2A) and after 4 weeks (Experiment 1). Analyses of between-group differences revealed that adult-provided supportive language did not facilitate recall when children were tested immediately after sequence demonstration (Experiment 2A); after a 4-week delay, however, children in the Full Narration group outperformed those in the Empty Narration group.

In a third experiment, the authors examined the effects of providing supportive language only at encoding or only at test when examining recall after a 4-week delay (Experiment 2B). Children in the Language at Encoding group were presented with Full Narration at encoding and Empty Narration at delayed recall, whereas children in the Language at Test group were provided with Empty Narration at encoding and Full Narration at delayed recall. The findings indicated that both groups of children showed evidence of recall after a 4-week delay, but that children in the Language at Test group outperformed children in the Language at Encoding group. The authors used these data to suggest that language at test served as a more effective retrieval cue than language used at encoding. Findings indicating that language provided at encoding did not facilitate delayed recall are somewhat surprising given recent work documenting the effects of encoding manipulations on recall memory in infancy and early childhood. For example, previous research has revealed that allowing children the opportunity for repeated exposures to to-be-remembered information facilitates delayed recall (Bauer, Wiebe, Waters, & Bangston, 2001); other manipulations indicate that permitting immediate imitation before the imposition of a 1-month delay (Bauer, Güler, Starr, & Pathman, 2011; Lukowski et al., 2005) and training children to criterion (Bauer et al., 2011) enhances delayed recall relative to when infants only watch the sequence demonstration. One goal of the present study was to further disentangle the contribution of adult-provided supportive language at encoding and adult-provided supportive language at test using a within-subjects design in children tested at 16 months.

A second goal of the present research was to examine an additional factor that may be associated with the extent to which preverbal children benefit from adult-provided supportive language at encoding and test: namely, child language comprehension abilities. Previous research has indicated that children as young as 13 months map associations between novel words and objects in engaging contexts with minimal demands on memory (Woodward, Markman, & Fitzsimmons, 1994; see also Oviatt, 1980, 1982, 1985). In a computer-based task, 14-month-olds mapped novel words onto moving stimuli but not onto those that were stationary, whereas younger children were unable to map novel words onto stimuli in either context (Werker, Cohen, Lloyd, Casasola, & Stager, 1998). By the time children are 18 months of age, they also map novel words onto actions, but this ability is not seen at 14 months (Casasola & Cohen, 2000). Taken together, these findings suggest that children are able to map novel words onto items before the "naming explosion"—a time in the second year of life marked by a significant growth in productive vocabulary (Benedict, 1979; Goldfield & Reznick, 1990; Gopnik & Meltzoff, 1986; Lifter & Bloom, 1989). Children may also be able to use the budding ability to make language-event associations to help support other cognitive functions, such as the ability to recall the past.

In sum, the goal of the present research was to determine whether child language comprehension abilities moderated the extent to which children benefitted from adult-provided supportive language at encoding and test in an elicited imitation procedure. We chose to test 16-month-old children, given previous research indicating that children map novel words onto novel actions between 14 and 18 months of age (Casasola & Cohen, 2000; Werker et al., 1998) and because the age of 16 months occurs within the period of rapid vocabulary acquisition reported by Goldfield and Reznick (1990). Although other work has examined the effect of adult-provided supportive language on recall memory after a 4-week delay in 18-month-old children (Hayne & Herbert, 2004), we tested recall after 1 week so as to allow our younger participants the best opportunity to maintain language-related information over the delay. We predicted that (1) child language comprehension and adult-provided supportive language at encoding would not be associated with performance at immediate imitation when memory representations are strong but that (2) child language comprehension would moderate the effect of supportive adult-provided language at encoding on performance at delayed recall. We also expected (3) significant positive correlations between measures of language comprehension and delayed recall performance, particularly when considering performance on sequences presented with the most linguistic support at encoding. If realised, these findings would be the first to demonstrate that adult-provided language differentially facilitates recall memory in early childhood in relation to child comprehension abilities.

METHOD

Participants

Thirty-four 16-month-old children (mean age = 16 months, 1 day; range from 15 months, 15 days to 16 months, 13 days; 15 girls) participated. An additional three children were recruited but did not complete the study (in all cases, the child became ill and the parent cancelled the second study session).

Families initially received a mass mailing about an opportunity to participate in research after the birth of one of their children; parents who were interested in participating provided their contact information online or on a postage-paid card that was mailed back to the researchers. All of the children were born at term (40 ± 2 weeks gestation) and were experiencing an apparently normal course of development. One parent did not return the questionnaire inquiring about race and ethnicity information. Of the remaining 33 children, 70% were of Caucasian descent, 15% were of mixed race and 3% were of American Indian descent; an additional 12% of parents chose not to report race information. Thirty-six per cent of the children were of Hispanic ethnicity (including the 12% of children whose parents chose not to report race information). Seventy-three per cent of mothers had earned at least a four-year college degree and 70% of families reported yearly incomes at or exceeding $75,000.

Materials and measures

Questionnaires. Parents provided demographic information on child's race and ethnicity, parental education and family income, among other things. Parents also reported whether English was the primary language used in the home and indicated the percentage of the time their child was exposed to English. Parents completed two additional questionnaires pertaining to child language development. The MacArthur-Bates Communicative Development Inventory: Words and Gestures (MCDI; Fenson et al., 2007), a validated and standardised measure of parent-reported language comprehension and production, was used to assess general child language production. An additional language questionnaire called the Specific Language Questionnaire (SLQ) was designed for use in this and related research (Phung, Milojevich, & Lukowski, 2014) and asked parents to indicate whether their child comprehended the sequence names and action phrases the experimenter used when presenting the event sequences during elicited imitation testing.

Elicited imitation. Children were presented with 6 three-step event sequences throughout the course of the study (an example sequence is shown in Figure 1). Each of the sequences was constrained by enabling relations, such that each of the three steps had to be completed in a certain order for the sequence goal-state to become apparent. However, the sequences were constructed so that children could perform the target actions in any order (meaning that it was not necessary to produce Step 1 of the sequence to receive credit for producing Step 2), although actions produced in the incorrect temporal order did not result in realisation of the sequence end-state. We employed sequences constrained by enabling relations so as to allow the children the best opportunity for recall, as children who are younger than 20 months of age perform at chance on sequences that are arbitrarily ordered (Wenner & Bauer, 1999).

Figure 1. Example of the three-step event sequence Make a Shaker. The left panel shows the first step of putting the block into one of the nesting cups; the middle panel shows the second step of assembling the nesting cups; the right panel shows the third step of shaking the assembled apparatus (although children also received credit for shaking only one of the nesting cups when the shaker was not fully assembled). Used with permission: Phung et al. (2014).

Procedure

The procedure was approved by the necessary institutional review boards; parents signed informed consent statements indicating their willingness to allow their children to participate. Each session was video recorded to allow for occasional protocol checks and offline data coding.

Questionnaires. Parents received the demographic questionnaire by mail and were instructed to complete it at home and return it at their first visit to the university. Parents completed the MCDI as their child participated in the elicited imitation assessment at the first session; parents who did not complete it at that time were asked to finish it at home and return it at the second session. Parents completed the SLQ as their child participated in the procedure at the second session; this questionnaire was not provided to parents earlier to ensure that they did not rehearse the sequence names and action phrases with their child during the 1-week delay between the sessions. Parents were asked to complete each language questionnaire considering only the words and phrases their children understood in English.

Elicited imitation. Children were tested by one of two female experimenters; the same experimenter tested children at each session. The primary experimenter tested approximately 65% of the participants; approximately 45% of the children tested by each experimenter were girls. The manipulated variables included the language that the experimenter used when demonstrating the event sequences at the first session (three levels of condition: maximally supportive, moderately supportive and minimally supportive) as well as the language that the researcher used to cue recall at the second session (two levels associated with phase: before the provision of the specific verbal prompt and total performance at the second session).

Once the child was seated across from the experimenter at a table, the experimenter initiated a warm-up activity in which she demonstrated how to roll a plastic ball across the tabletop and place it inside of a slinky twice in succession with narration; the child was encouraged to imitate the presented actions. This warm-up activity has been used previously (Bauer & Dow, 1994; Bauer et al., 1995; Bauer, Wenner, Dropik, & Wewerka, 2000; Bauer & Wewerka, 1995) to familiarise the child with the experimenter and to introduce the child to the turn-taking format of the elicited imitation procedure.

After the child appeared comfortable with the experimenter, each child was presented with six novel three-step event sequences. During the baseline phase of testing, children were presented with the props along with a general verbal prompt ("What can you do with this stuff?"). The baseline phase ended when the children engaged in repetitive off-task or exploratory behaviours, such as mouthing the props, dropping them repeatedly on the floor or banging them on the table (Bauer et al., 2000; Bauer & Hertsgaard, 1993). Once the baseline period was complete, the experimenter modeled each sequence of actions twice in succession with narration.

The primary experimental manipulation at the first session was the within-subjects condition to which the event sequences were assigned. Two sequences were presented in each of three conditions; the order in which the sequence conditions were presented was counterbalanced and the sequences were block randomised to ensure that each sequence was presented approximately equally as often in each condition. The sequences within each block were also counterbalanced to ensure that each one was presented first or second approximately equally as often. For the two sequences presented in the maximally supportive condition, the experimenter provided the child with the name of the sequence and narrated the completion of each of the three actions. When preparing to Make a Shaker, for example, the experimenter put the props on the table and said, "I can use this stuff to Make a Shaker. Watch how I Make a Shaker". She then narrated each action as it was completed by saying, "Put in the block. Cover it up. Shake it". For the two sequences presented in the moderately supportive condition, the experimenter provided the child with the name of the sequence but provided empty narration in place of the action phrases. In this condition, the experimenter put the props on the table and said, "I can use this stuff to Make a Shaker. Watch how I Make a Shaker." She then narrated each action as it was completed using language such as, "See this part. Look at this thing. Watch this." For the two sequences presented in the minimally supportive condition, the experimenter provided empty narration in place of both the name of the sequence and the action phrases. For example, the experimenter may have said, "Look what I can do with these things", as she set the props on the table. As she completed each of the three actions, she used language such as, "Watch what this does. Look at this piece. Check out this thing". Because the sequence names and action labels in the maximally supportive condition were specific to the particular sequences being used, the empty narration presented in the moderately and minimally supportive conditions was also unique, although similar in content. The empty phrases were created before testing began and were randomised across sequences in the moderately and minimally supportive conditions at the first session.

After each sequence was modeled by the experimenter, the children were allowed an opportunity for immediate imitation as an index of encoding (Bauer, 2005; Bauer & Lukowski, 2010; Bauer et al., 2000; Bauer et al., 2011; Hayne & Herbert, 2004; Herbert & Hayne, 2000). As the experimenter gave the sequence materials to the children, she provided a general verbal prompt to encourage interaction with them ("What can you do with this stuff?"). Children interacted with the props until they engaged in the repetitive exploratory or off-task behaviours described previously. After the immediate imitation phase was complete, the experimenter demonstrated each event sequence once again using the same language as when she modeled the sequence initially (see Bauer & Lukowski, 2010; Phung et al., 2014).

Children returned to the laboratory after approximately 1 week for an assessment of delayed recall (mean delay = 7 days; range from 6 days to 9 days). After a brief warm-up period, children were presented with the six sequences that were shown at the first session in a new counterbalanced order. Delayed recall was assessed for each sequence in turn using a within-subjects procedure that incorporated components of both Empty and Full Narration (see Bauer et al., 2000; Phung et al., 2014). Specifically, the experimenter placed the props on the table and pushed them towards the child while initially providing a general verbal prompt to encourage interaction with the presented materials ("What can you do with this stuff?"). When the children engaged in repetitive exploratory or off-task behaviours, the experimenter provided the child with the name of the event sequence as an additional sequence-specific mnemonic cue ("You know, you can use this stuff to Make a Shaker. How do you Make a Shaker with this stuff?"). Children interacted with the sequence materials until they again engaged in the repetitive exploratory or off-task behaviours described previously.

Data reduction

Questionnaires. The data from the language questionnaires were coded and reduced to yield information about child comprehension abilities as described previously (see Phung et al., 2014). General language comprehension was derived from the MCDI by counting the number of vocabulary words parents indicated their child understood (average number of comprehended words = 187, range from 38 to 396 words). Because of our goal of examining relations between general language comprehension and mnemonic performance by phase, we assigned children into high (n = 17) and low (n = 17) comprehension groups using a median split (median = 170 words) (for a similar analytical approach, see Graf Estes, Edwards, & Saffran, 2011). The one child whose comprehension score was on the median was assigned to the Low Comprehension group so as to create equal groups of participants; we also reasoned that including a child with relatively high comprehension scores in the Low Comprehension group would work against us by reducing the likelihood of obtaining significant group differences. Data from the SLQ were reduced to determine the total number of sequence names (maximum = 2) and action *phrases* (maximum = 6) children comprehended by condition. The data from the demographic questionnaire were reduced to provide information about sample characteristics and to indicate whether children in the High and Low Comprehension groups differed on any relevant background characteristics.

Elicited imitation. The two experimenters were trained on data-coding procedures before participant testing began using an existing data-set. The experimenters then coded the elicited imitation data online as it was being collected (Bauer & Lukowski, 2010; Bauer et al., 2011; Phung et al., 2014). The experimenters recorded both the occurrence of individual target actions and their order. Individual target actions were coded when the child completed any of the three actions modelled by the experimenter; temporal order information was coded by recording the order in which the target actions were completed. As has been done in previous research, only the first occurrence of each behaviour was coded so as to reduce the likelihood of obtaining credit for behaviours produced by chance or trial and error, thereby providing the most conservative measure of recall (Bauer & Dow, 1994; Bauer, Hertsgaard, Dropik, & Daly, 1998; Bauer et al., 2000;). A third coder who was unaware of the hypotheses watched the videotapes and recoded the data for approximately 35% of the sample (n = 12, including eight children tested by the primary experimenter and four children tested by the secondary experimenter). Reliability values were acceptable for each pair of coders (reliability coder and primary experimenter: mean = 91%, range from 82% to 100%; reliability coder and secondary experimenter: mean = 91%, range from 88% to 95%).

The average number of target actions (maximum = 3) and pairs of actions produced in the correct temporal order (maximum = 2) were reduced by phase (baseline and immediate imitation at the first session, before the provision of the specific verbal reminder and total performance at the second session) and condition (maximally supportive, moderately supportive and minimally supportive). The test phase before the provision of the specific verbal reminder at the second session allowed for examination of the extent to which the props alone served as an effective retrieval cue after the delay; total performance at the second session accounts for any additional facilitating effects of providing the sequence name (Bauer et al., 2000; Phung et al., 2014). We analysed performance on target actions so as to maintain consistency with the existing literature, which only documents associations between adult-provided linguistic support and the retention of individual target actions. We also analysed pairs of actions produced in the correct temporal order as well so as to examine an additional aspect of memory for which there is no information inherent in the sequence materials themselves. That is, although the perceptual features of the sequence materials might serve to cue recall of individual target actions, there is no information in the materials themselves to cue the order in which the demonstrated actions should be completed to realise the sequence goal-state (Bauer, 1997).

RESULTS

Determination of potential covariates

We initially examined whether continuous measures of language comprehension were associated with potentially relevant demographic characteristics, namely, participant sex (coded dichotomously as 0 = male, 1 = female), maternal education (coded on an ordinal scale from 0 = no high school to 6 = graduate or professional degree), annual family income (coded on an ordinal scale from 0 = less than $24,000 to 6 = $200,000 or more), and the percentage of the time participants were exposed to English (coded dichotomously as 0 = less than 50% of the time, 1 = 50% of the time or more). We also determined whether participant sex, maternal education and annual family income differed by comprehension group. Results are presented when $p < .05$.

Correlations indicated that child sex was negatively associated with the comprehension of the sequence names: $r(32) = -.35$, $p = .04$, and action phrases used during elicited imitation testing: $r(32) = -.44$, $p = .009$. Child sex was also negatively associated with some aspects of elicited imitation performance at the second session, particularly the recall of target actions on sequences presented in the maximally supportive condition before the provision of the specific verbal prompt: $r(32) = -.43$, $p = .01$, and in total at the second session: $r(32) = -.43$, $p = .01$. Given these significant associations, we included child sex as a categorical covariate in the subsequent analyses.

The High and Low Comprehension groups did not differ on child sex or maternal education, although children in the High Comprehension group had families with greater annual incomes (3.67 ± .38) relative to children in the Low Comprehension group: (2.54 ± .37): $F(1, 30) = 4.46$, $p = .04$, $\eta_p^2 = .13$. Correlations revealed that annual income was not associated with elicited imitation performance at either session and was not included as a covariate in subsequent analyses for this reason.

Parents reported that children in the High Comprehension group understood a greater number of words on the MCDI (266.48 ± 14.52) relative to children in the Low Comprehension group (107.81 ± 14.52): $F(1, 31) = 57.09$, $p = .0001$, $\eta_p^2 = .65$. Group differences were not found when considering the total number of sequence names comprehended on the SLQ, although parents indicated that children in the High Comprehension group understood a greater number of action phrases (9.85 ± .74) relative to children in the Low Comprehension group (6.45 ± .74): $F(1, 31) = 10.08$, $p = .003$, $\eta_p^2 = .25$. Despite these differences in relations between comprehension group and performance on the two language questionnaires, MCDI comprehension was significantly correlated with the total number of sequence names: $r(29) = .44$, $p = .01$, and action phrases comprehended on the SLQ: $r(29) = .59$, $p = .0001$.

Elicited imitation

The elicited imitation data are shown in Table 1. These data were analysed separately for target actions and pairs of actions completed in the correct temporal order by conducting two 2 (group: high or low language comprehension) × 3 (condition: maximally, moderately and minimally supportive) × 4 (phase: baseline at the first session, immediate imitation at the first session, before the provision of the specific verbal prompt at the second session and total performance at the second session) analysis of covariance (ANCOVA) controlling for child sex. So as to simplify the presentation of the results, all main effects and interactions are reported below, but the data are only interpreted in the context of the highest-order significant interaction obtained for target actions and pairs of actions completed in the correct temporal order.

Significant main effects of phase were found when considering target actions: $F(3, 93) = 40.60$, $p = .0001$, $\eta_p^2 = .57$, and pairs of actions completed in the correct temporal order: $F(3, 93) = 24.47$, $p = .0001$, $\eta_p^2 = .44$. Significant main effects of group were also found for target actions: $F(1, 31) = 4.94$, $p = .03$, $\eta_p^2 = .14$, and pairs of actions: $F(1, 31) = 6.24$, $p = .02$, $\eta_p^2 = .17$.

The aforementioned main effects of phase and group were qualified by a significant Phase × Group interaction for pairs of actions completed in the correct temporal order: $F(3, 93) = 3.68$, $p = .02$, $\eta_p^2 = .11$; these data are shown in Figure 2. Follow-up pairwise comparisons conducted by group revealed similar effects by phase, such that relative to baseline, children in both groups performed more pairs of actions at immediate imitation (both *p*s = .0001), before the provision of the specific verbal prompt (both *p*s = .0001) and in total at the second session (both *p*s = .0001). This pattern of results was similar across groups when comparing performance at immediate imitation to recall after the 1-week delay, such that performance at immediate imitation did not differ in relation to performance before the provision of the specific verbal prompt or in total at the second session for children in both groups. Group differences in performance were apparent, however, when examining performance at the second session, such that total performance exceeded that before the provision of the specific verbal prompt for children in the High Comprehension group ($p = .005$) but not for children in the Low Comprehension group. Pairwise comparisons conducted by phase revealed no group differences in performance at baseline or immediate imitation, whereas children in the High Comprehension group completed more pairs of actions before the provision of the specific verbal prompt ($p = .02$) and in total at the second session

TABLE 1
Recall memory by group, condition and phase, controlling for child sex (means and standard errors)

	Sequence condition			
	Maximally supportive	*Moderately supportive*	*Minimally supportive*	*Overall (across conditions)*
		Panel A: target actions		
High Comprehension group				
Baseline	.74 ± .14	1.02 ± .11	.64 ± .11	.80 ± .08
Immediate imitation	1.84 ± .20	1.54 ± .16	1.69 ± .20	1.69 ± .11
Before specific prompt	1.77 ± .14	1.54 ± .14	1.38 ± .16	1.56 ± .10
Overall performance	1.83 ± .13	1.76 ± .15	1.55 ± .16	1.72 ± .10
Low Comprehension group				
Baseline	.88 ± .14	.72 ± .11	.57 ± .11	.72 ± .08
Immediate imitation	1.54 ± .20	1.37 ± .16	1.20 ± .20	1.37 ± .11
Before specific prompt	1.09 ± .14	1.17 ± .14	1.44 ± .16	1.23 ± .10
Overall performance	1.23 ± .13	1.40 ± .15	1.53 ± .16	1.38 ± .10
Overall (across groups)				
Baseline	.81 ± .10	.87 ± .08	.60 ± .08	.76 ± .05
Immediate imitation	1.69 ± .14	1.46 ± .11	1.44 ± .14	1.53 ± .08
Before specific prompt	1.43 ± .09	1.35 ± .10	1.41 ± .11	1.40 ± .07
Overall performance	1.53 ± .09	1.57 ± .10	1.54 ± .11	1.55 ± .07
		Panel B: pairs of actions completed in the correct temporal order		
High Comprehension group				
Baseline	.19 ± .08	.12 ± .05	.14 ± .07	.15 ± .03
Immediate imitation	.93 ± .17	.55 ± .13	.73 ± .13	.73 ± .08
Before specific prompt	.78 ± .11	.61 ± .10	.53 ± .12	.64 ± .07
Overall performance		.70 ± .09	.68 ± .12	.73 ± .07
Low Comprehension group				
Baseline	.17 ± .08	.09 ± .05	.13 ± .07	.13 ± .03
Immediate imitation	.60 ± .17	.57 ± .13	.42 ± .13	.53 ± .08
Before specific prompt	.28 ± .11	.34 ± .10	.56 ± .12	.39 ± .07
Overall performance	.31 ± .10	.42 ± .09	.59 ± .12	.44 ± .07
Overall (across groups)				
Baseline	.18 ± .06	.10 ± .04	.13 ± .05	.14 ± .02
Immediate imitation	.77 ± .12	.56 ± .09	.57 ± .09	.63 ± .06
Before specific prompt	.53 ± .07	.47 ± .07	.54 ± .08	.52 ± .05
Overall performance	.56 ± .07	.56 ± .06	.63 ± .08	.58 ± .05

(p = . 004) relative to children in the Low Comprehension group.

A significant three-way interaction among comprehension group, phase and condition was found for target actions: $F(6, 186) = 3.04$, $p = .007$, $\eta_p^2 = .09$.[1] Follow-up simple effects analyses were conducted by examining whether effects of group, condition or their interaction were apparent at each of the four levels of phase (additional information on the other simple effects analyses can be obtained from the first author). Performance at baseline and immediate imitation did not differ by group, condition or their interaction for either dependent measure. A significant main effect of group was found when examining the number of target actions completed before the provision of the specific verbal prompt at the second session: $F(1, 31) = 5.13$, $p = .03$, $\eta_p^2 = .14$. This effect was also included in *a* significant Condition × Group interaction, as shown in Figure 3: $F(2, 62) = 3.99$, $p = .02$, $\eta_p^2 = .11$. We further explored this interaction by examining the effect of comprehension group at each level of condition. The results indicated that children in

[1] A supplemental regression analysis was conducted using XTMIXED in STATA to determine whether the continuous measure of child language comprehension on the MCDI moderated the effect of supportive adult-provided language at encoding on recall after the 1-week delay controlling for infant sex. The results revealed a significant three-way interaction amongst the included factors: $\chi^2(6) = 6.96$, $p = .03$. Additional follow-up analyses conducted by phase revealed that the significant association between language comprehension and condition was maintained only when examining performance before the provision of the specific verbal prompt: $\chi^2(2) = 8.42$, $p = .01$. As such, these analyses including continuous language comprehension replicated that interactions that are reported for target actions in the text.

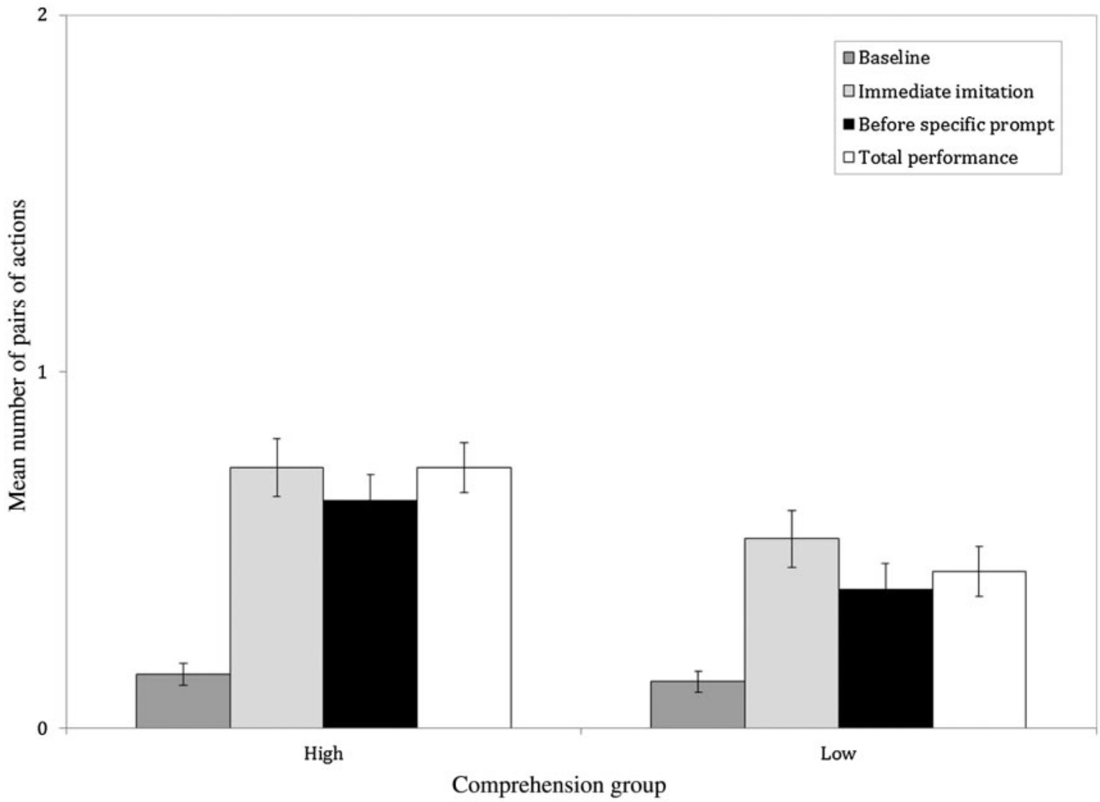

Figure 2. Significant Group × Phase Interaction for pairs of actions completed in the correct temporal order (means ± standard errors). Findings revealed that relative to baseline, children in both groups performed more target actions at immediate imitation, before the specific verbal prompt and in total at the second session. For children in the High Comprehension group only, total performance at the second session also exceeded that before the provision of the specific verbal prompt. In addition, relative to children in the Low Comprehension group, children in the High Comprehension group performed more target actions before the provision of the specific verbal prompt and in total at the second session.

the High Comprehension group produced more target actions on sequences presented in the maximally supportive condition relative to children in the Low Comprehension group (p = .001). We then examined whether the effect of adult-provided supportive language at encoding differed by group. The findings revealed that children in the High Comprehension group produced more target actions on sequences presented in the maximally supportive condition relative to the minimally supportive condition (p = .03); the opposite effect was found for children in the Low Comprehension group, such that these children performed more target actions in the minimally supportive condition relative to the maximally supportive condition (p = .04). Analyses conducted on total performance at the second session revealed only a significant main effect of group, such that children in the High Comprehension group outperformed children in the Low Comprehension group: $F(1, 31) = 5.71$, $p = .02$, $\eta_p^2 = .16$.

Continuous relations among language comprehension and elicited imitation performance

Correlational analyses were conducted as described in Phung et al. (2014).

Baseline. Correlations between the elicited imitation data from the baseline assessment and parent report of child comprehension on the MCDI and SLQ were conducted by collapsing across condition, as there were no procedural or performance differences by condition at baseline. There were no significant associations between language comprehension on the MCDI or the SLQ in relation to baseline performance (rs from .01 to .26).

Immediate imitation and delayed recall. Correlations examining language comprehension scores in relation to performance at (1) immediate imitation and (2) delayed recall are

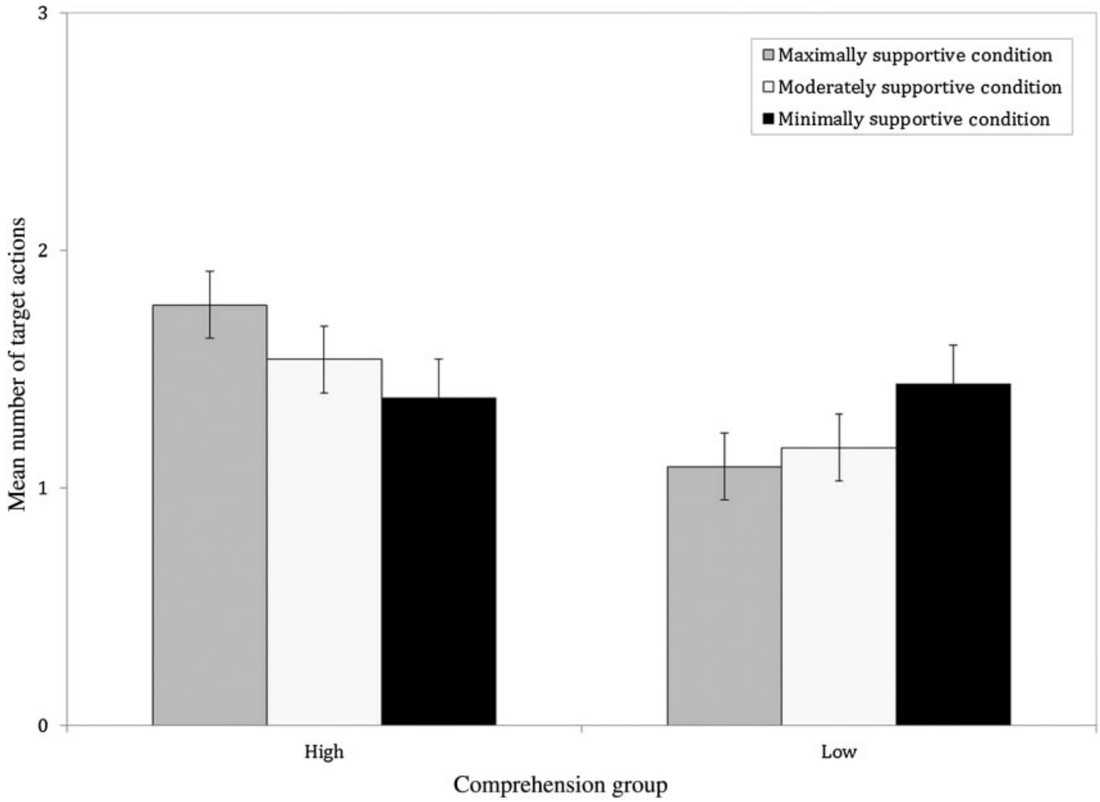

Figure 3. Simple effects analyses on the significant Group × Condition × Phase analysis yielded a significant Group × Condition interaction before the provision of the specific verbal prompt for target actions (means ± standard errors). Findings revealed that children in the High Comprehension group performed more target actions on sequences presented in the maximally supportive condition relative to children in the Low Comprehension group. In addition, children in the High Comprehension group produced more target actions on sequences presented in the maximally supportive condition relative to the minimally supportive condition, whereas the opposite pattern was found for children in the Low Comprehension group.

shown in Table 2. The complete set of correlations is shown for sequences presented in the maximally supportive condition, as children were provided with the sequence names and action phrases for these events at the first session. Correlations involving the comprehension of the action phrases are not shown for sequences presented in the moderately and minimally supportive conditions, as children were never provided with these phrases during testing. Similarly, correlations involving the comprehension of sequence names are only shown for sequences presented in the minimally supportive condition in relation to total delayed recall, as sequence names were only provided to participants when the specific verbal prompts were provided at the second session. We chose not to examine the omitted correlations because their interpretation would be tenuous, given that participants were not exposed to these particular phrases during elicited imitation testing.

One significant correlation was obtained when examining associations between language comprehension and performance at immediate imitation, such that general language comprehension on the MCDI was positively associated with the performance of target actions on sequences presented in the moderately supportive condition. A greater number of significant correlations were apparent when considering associations between language comprehension and performance at delayed recall. General language comprehension as assessed by the MCDI was positively related to the production of target actions and pairs of actions on sequences presented in the maximally supportive condition both before the provision of the specific verbal reminder and in total at the second session; comprehension of the sequence names and action phrases on the SLQ was unrelated to performance at the second session.

TABLE 2
Correlations between language comprehension and recall memory performance controlling for child sex

	Sequence condition					
	Maximally supportive		*Moderately supportive*		*Minimally supportive*	
	Target actions	*Pairs of actions*	*Target actions*	*Pairs of actions*	*Target actions*	*Pairs of actions*
Immediate imitation at the first session						
MCDI comprehension	.08	.03	.40*	.22	.25	.17
SLQ sequence names	−.03	−.07	.05	−.02	–	–
SLQ action phrases	.06	.00	–	–	–	–
Before the provision of the specific verbal reminder at the second session						
MCDI comprehension	.42*	.37*	.12	.17	−.14	−.16
SLQ sequence names	.05	.13	−.12	−.03	–	–
SLQ action phrases	.25	.15	–	–	–	–
Total delayed recall performance at the second session						
MCDI comprehension	.40*	.39*	.08	.19	−.10	−.03
SLQ sequence names	−.01	.08	.13	.03	−.10	−.21
SLQ action phrases	.23	.18	–	–	–	–

Asterisks denote findings significant at $p < .05$.

DISCUSSION

The present study was conducted to determine whether child language comprehension abilities moderated the extent to which children benefitted from adult-provided supportive language at encoding and test in a recall memory task. As predicted, language comprehension group and sequence condition were unassociated with recall performance at baseline or immediate imitation. Instead, child language comprehension moderated the extent to which children benefitted from supportive adult-provided language at encoding and test when tested after a 1-week delay. On sequences presented in the maximally supportive condition, before the provision of the specific verbal prompt at the second session, children in the High Comprehension group performed more target actions and pairs of actions than children in the Low Comprehension group. Group differences in performance by condition were also found at this phase of testing. As expected, before the provision of the specific verbal prompt, children in the High Comprehension group performed more target actions on sequences presented in the maximally supportive condition relative to the minimally supportive condition; somewhat surprisingly, the opposite effect was found for children in the Low Comprehension group, such that they performed more target actions on sequences presented in the minimally supportive condition relative to the maximally supportive condition. Although sequence condition did not emerge as a relevant factor when considering total performance at the second session, children in the High Comprehension group performed more target actions and pairs of actions relative to children in the Low Comprehension group.

Correlations were also informative in explaining relations among adult-provided supportive language, child language comprehension and delayed recall memory. As we had expected, significant positive correlations were found between general language comprehension on the MCDI and performance on sequences presented in the maximally supportive condition both before the provision of the specific verbal prompt and in total at the second session. Correlations did not reveal relations between child comprehension of the specific words and phrases used during sequence presentation and recall memory. Taken together, these data suggest that general indices of language comprehension are better predictors of 1-week delayed recall memory relative to comprehension of the specific words and phrases used during sequence demonstration.

These data add to those that have been reported previously in that we demonstrate effects of adult-provided supportive language at encoding and test that are moderated by *children's* language comprehension abilities; previous findings revealed that supportive language provided only at test facilitated 4-week delayed recall in 18-month-olds relative to supportive language provided only at encoding and did not consider child comprehension abilities as a potential moderator (Hayne & Herbert, 2004; Experiment 2B). Our data suggest that supportive language provided at encoding facilitated 1-week delayed recall in 16-month-old children from the High Comprehension group. We have previously suggested that our findings indicating the facilitating effect of language at encoding may be due to the shorter between-session delay imposed on our work relative to the 4-week delay used by Hayne and Herbert (2004; Phung et al., 2014). Specifically, as reported in our other work, examination of the mean recall scores provided by Hayne and Herbert across experiments reveal that children tested in the Language at Encoding group in Experiment 2B (.67 ± .16) performed similarly to the children tested in the Empty Narration group in Experiment 1 (.80 ± .17) after 4-week delays. Although the researchers did not examine whether children mapped the provided language onto the event sequences at the first session or maintained the learned information over the 4-week delay, one possible explanation for their findings is that children in the Language at Encoding group forgot the presented supportive language over the lengthy delay, thereby resulting in a performance that resembled that of children who did not receive any informative linguistic cues. Although we also did not assess the encoding and retention of language-event relations, one potential explanation of these findings may be that children in the High Comprehension group retained language-related information over the course of the 1-week delay, as performance differences were found before the provision of the specific verbal prompt at the second session.

One possible mechanism underlying the obtained pattern of findings is that children in the High Comprehension group may have been better able to map language-related information onto the event sequences as they were being presented at the first session and retain that information over time. Conversely, children in the Low Comprehension group may have been less able to map and maintain language-event associations as reflected by their reduced performance on sequences presented in the maximally supportive condition before the provision of the specific verbal prompt. Our data suggest that for children in the Low Comprehension group in particular, adult-provided supportive language at encoding may actually be *detrimental* to recall performance over the long term, such that these children produced more target actions and pairs of actions on sequences presented in the minimally supportive condition relative to the maximally supportive condition. Although the mechanism responsible for this finding remains to be determined, one possibility is that children in the Low Comprehension group *devoted* their cognitive resources to (unsuccessfully) processing the sequence-specific language provided at the first session, resulting in fewer available resources to expend on the processing of event-related information. Intriguingly, performance at immediate imitation did not differ between children in the High and Low Comprehension groups but varied before the provision of the specific verbal prompt and in total at the second session, suggesting that between-group processing of language-event related information may diverge during consolidation and storage processes occurring during the 1-week delay. Future research studies should test these hypotheses so as to better understand (1) whether children map linguistic information onto the presented event sequences, (2) whether they maintain that information over the delay, (3) whether the mapping and maintenance of linguistic information is moderated by child language comprehension and (4) whether the encoding and maintenance of language-related information differentially predict recall performance after a 1-week delay.

Nevertheless, findings from the presented correlations indirectly lend some credibility to our suggestion that children in the High Comprehension group are better at encoding and maintaining language-event relations than are children in the Low Comprehension group. Correlations revealed no associations between child language comprehension and baseline performance, whereas associations between MCDI comprehension scores and recall performance were found at immediate imitation for sequences presented in the moderately supportive condition and before the provision of the specific verbal prompt and in total at the second session on sequences presented in the maximally supportive condition; child comprehension of the specific words and phrases used during elicited imitation testing was unrelated to event memory in all conditions at any phase of testing. These findings suggest that a prior knowledge of event-related language did not facilitate performance at the second session and instead points to a general effect of better language comprehension on recall performance. We suggest that children with better general comprehension skills may be those children who are also better at creating and maintaining language-event associations. In support of this prediction, previous research indicates that receptive vocabulary is associated with novel word learning at 18 months, such that children with higher MCDI comprehension scores were able to discriminate between plausible and implausible object labels in a word learning task, whereas children with lower comprehension scores were not (Graf Estes et al., 2011). As we reported previously (Phung et al., 2014), we do not believe that the group differences in elicited imitation performance before the provision of the specific verbal prompt at the second session are associated with general measures of intelligence or cognitive competency, although language comprehension has been associated with later IQ (Bornstein & Hayes, 1998; Rose, Feldman, Wallace, & Cohen, 1991). If children in the High Comprehension group were more cognitively adept than children in the Low Comprehension group, we would have expected them to demonstrate better trial-and-error problem-solving abilities at baseline relative to children in the Low Comprehension group; group differences in performance would also have been expected at the other phases of testing. As an additional support for this argument, group differences were not observed on maternal education, a demographic factor that has been associated with child comprehension abilities in other research (Bornstein & Hayes, 1998).

Future research should address the limitations of the current study. First, future research should include a standardised measure of general developmental ability, such as the Bayley Scales of Infant and Toddler Development (Bayley, 2006), so as to ensure that children in the High and Low comprehension groups do not differ in developmental level. Second, future investigations into the use of adult-provided supportive language at encoding and test should include nonsense words with which children do not have any previous experience instead of words and phrases children may know from outside the laboratory setting. Researchers could then more definitively examine whether children mapped the presented language onto the demonstrated event sequences during testing instead of having a priori knowledge of word meaning.

Finally, future research should include additional control conditions to ensure that differences in performance at the second session result only from the manipulation of supportive adult-provided language at that time. In the present study, we could not determine whether the provision of the specific verbal prompt impaired recall performance for some of the children, as imitation scores could only remain the same or increase across these two phases of testing. Similarly, our findings did not reveal how children would perform on the elicited imitation task without any supportive language provided at test. To address these limitations, future researchers should assess delayed recall using a between-subjects design in which some participants are presented with a general verbal prompt at delayed recall, whereas others are presented with a specific prompt. An alternative approach could feature a within-subjects design in which various event sequences were tested in each of two independent conditions (i.e., three sequences tested with a general verbal prompt and three sequences tested with a specific verbal prompt). Children should also be tested in a no-language condition in which the only retrieval cue is the presented sequence materials. The imposition of these experimental variations would allow for better characterisation of the importance of adult-provided language at delayed recall and would establish whether children's comprehension of English moderates the extent to which children benefit from adult-provided verbal cues at test.

Despite these significant and important avenues for future research, the present study is the first to document novel associations amongst child language comprehension, adult-provided supportive language at encoding and test and recall memory in children tested at 16 months. The findings reveal that the influence of supportive adult language at encoding and test are not best described by main effects but instead are moderated by child comprehension abilities. These findings are of theoretical importance for understanding infantile amnesia, such that they suggest that children use adult-provided language to structure their event memories before they have the capacity to discuss them verbally. They are also of practical importance in that children likely use adult-provided language to structure their own event memories outside of the laboratory before they can talk about them. As such, when talking with children about the past, parents should use language commensurate with the comprehension abilities of their children. In particular, parents should avoid use of language that may be too complex for children to understand, as such language might actually hinder, rather than facilitate, memory for the past. Indeed, future work remains to be conducted to identify the youngest ages at which children benefit from adult-provided supportive language and to determine how other contextual factors such as parent language use at home is associated with the development of event memory in infancy and early childhood. Nevertheless, the presented findings reveal that the complex interplay between language and cognition is established in early childhood, with foundational relations emerging before children are even capable of verbally reporting on the past.

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