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Adult language use and infant comprehension of English: Associations with encoding and generalization across cues at 20 months

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ABSTRACT

Adult-provided language shapes event memory in children who are preverbal and in those who are able to discuss the past using language. The research conducted to date, however, has not yet established whether infant language comprehension abilities moderate the extent to which preverbal infants benefit from adult-provided supportive language. The present study was conducted to address this question by examining immediate imitation and 1-week delayed generalization across cues in 20-month-old infants as a function of (a) variability in adult-provided linguistic support at encoding and test, (b) infant language comprehension abilities, and (c) their interaction. The provision of supportive adult language at encoding and test was associated with delayed generalization across cues although supportive adult language at encoding did not influence performance at immediate imitation. Infant language comprehension abilities were associated with performance at immediate imitation and delayed generalization across cues. In addition, infant language comprehension abilities moderated the extent to which infants benefited from adult-provided supportive language at encoding and test. The findings contribute to the literature by demonstrating that adult language use and infant language comprehension are independently and differentially associated with immediate imitation and 1-week delayed generalization across cues but also serve to jointly structure event memory in the second year of life.

1. Introduction

Adult language use shapes event memory in childhood. Previous research has indicated that the information children recall is associated both with adult–child conversations that occur as an event unfolds (for example, Boland, Haden, & Ornstein, 2003; Haden, Ornstein, Eckerman, & Didow, 2001; McGuigan & Salmon, 2004, 2006) and with adult–child conversations about the past (Conroy & Salmon, 2006; Fivush, 1991; Fivush & Fromhoff, 1988; Haden, Haine, & Fivush, 1997; Hudson, 1993; Reese, Haden, & Fivush, 1993). The facilitating effect of adult language use has also been documented in infants and children who are not yet capable of verbally reporting on the past themselves (referred to as "preverbal" in this report), such that supportive adult language use has been associated with enhanced recall memory (Hayne & Herbert,

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2004) and delayed generalization across cues (Herbert, 2011). One potentially important factor that may be associated with the extent to which preverbal infants benefit from adult-provided language is infant comprehension abilities. Although a limited literature documents associations between language comprehension and recall memory in those who cannot verbally recount the past (Heimann et al., 2006), research has not yet been conducted to our knowledge to examine whether language comprehension moderates the extent to which preverbal infants use adult-provided language to structure their event memories. The present study was conducted to address this question by examining immediate imitation and 1-week delayed generalization across cues in 20-month-old infants as a function of (a) variability in adult-provided linguistic support at encoding and test, (b) infant language comprehension abilities, and (c) their interaction.

As indicated, both experimental studies (for examples, see Boland et al., 2003; Conroy & Salmon, 2006; Haden et al., 2001; Hudson & Nelson, 1993; McGuigan & Salmon, 2004; Peterson, Jesso, & McCabe, 1999; Tessler & Nelson, 1994) and naturalistic research (for examples, see Fivush, 1991; Fivush & Fromhoff, 1988; Haden et al., 1997; Hudson, 1993; Reese et al., 1993) alike support the notion that adult-provided language is associated with recall memory in children who are old enough to verbally report on the past. In particular, more supportive adult language use has been associated with more accurate recall (Boland et al., 2003; Conroy & Salmon, 2006; McGuigan & Salmon, 2004; Tessler & Nelson, 1994) as well as with more complex or dense accounts of past events (Fivush, 1991; Fivush & Fromhoff, 1988; Peterson et al., 1999; Reese et al., 1993). The extent to which adult-provided language facilitates recall memory and related abilities in preverbal infants is somewhat less well established. Part of the challenge in understanding the influence of adult language use on recall memory and related abilities in the first years of life is methodological: these individuals cannot report on their past experiences using language. Because of this limitation, recall memory and related abilities are commonly assessed behaviorally using the elicited or deferred imitation procedure. In one version of this procedure, infants interact with novel stimuli during a brief baseline period before watching as a researcher models a sequence of actions. The infant is then allowed to interact with the stimuli either immediately (elicited imitation), after a delay (deferred imitation), or both. The data are coded to determine whether the infant performs the actions that were modeled by the experimenter and whether they were completed in the correct temporal order (see Bauer, DeBoer, & Lukowski, 2007, for additional information on the elicited imitation procedure).

Research examining the influence of adult-provided linguistic support on recall memory and related abilities indicates that adult-provided language influences memory in preverbal infants, particularly after a delay. In one early study, Bauer, Hertsgaard, and Wewerka (1995) presented 15-month-old infants with three-step event sequences. The experimenter provided the name of each event sequence and modeled the three actions along with the name of the event and narration of the demonstrated actions. Immediate imitation was permitted and was cued by presenting infants with the sequence materials and the name of the event. Delayed recall was assessed after 1 week and was cued by presenting the sequence materials along with the name of the event for infants in the Verbal Reminder group; recall was cued by presenting the sequence materials only for infants in the No Verbal Reminder group. Infants in both groups encoded and recalled the demonstrated actions and their order relative to baseline. Group-related differences in forgetting were apparent, however, such that infants tested in the No Verbal Reminder group evidenced significant forgetting over the 1-week delay whereas infants tested in the Verbal Reminder group did not. These findings demonstrate that the provision of a verbal reminder at test in combination with supportive language at encoding effectively reduced forgetting.

More recent research has systematically investigated the influence of variability in adult-provided linguistic support at both encoding and test on recall memory in preverbal infants. Hayne and Herbert (2004; Experiment 1) presented 18-month-olds with three-step event sequences in one of two groups; delayed recall was tested after 4 weeks. At the first session, infants enrolled in the Full Narration group viewed the sequence demonstration as the experimenter provided the name of the event and narrated the three actions as they were completed; recall was cued at the second session by providing infants with the sequence materials along with the name of the event. Infants enrolled in the Empty Narration group viewed the sequence demonstration as the experimenter provided language that did not provide any meaningful information about the event ("Let's have a look at this. Then we have this bit. That was pretty neat, wasn't it?", p. 131); recall was cued at the second session by providing the infants with the sequence materials along with a general verbal prompt. The results indicated that both groups of infants recalled the target actions relative to control groups that had not seen the modeled actions. Infants tested in the Full Narration group, however, performed more target actions after the 4-week delay relative to infants in the Empty Narration group.

In another study, Hayne and Herbert (2004; Experiment 2A) examined whether the facilitative effect of full narration would also be observed at encoding, as indexed by immediate imitation. The authors used the same linguistic support manipulation as in Experiment 1 but tested recall immediately after the sequences were modeled. The results indicated that infants in both groups performed more target actions at immediate imitation relative to a control group that had not seen the modeled actions. The authors suggested that full narration did not affect performance at immediate imitation and speculated that adult-provided supportive language at test may be a more effective mnemonic cue than supportive language provided at encoding. They then tested this hypothesis in their final experiment (Experiment 2B).

To further disentangle the independent contributions of supportive adult language provided at encoding or test on long-term recall memory, Hayne and Herbert (2004; Experiment 2B) manipulated the timing of linguistic support and observed effects on recall memory after a 4-week delay. Infants in the Language at Encoding group were presented with the sequence materials along with the name of the event and narration of the demonstrated actions at the first session; at the second session, these infants were provided with the sequence materials along with a general verbal prompt ("What can we do with these things?", p. 136). The infants in the Language at Test group were presented with the sequence materials and empty narration (similar to that used in Experiments 1 and 2A) at the first session; at the second session, they were provided with the sequence materials along with a verbal reminder of the sequence name. The findings indicated that both groups of infants recalled the target actions relative to a control group. Between-group differences in performance were also apparent at the second session, however, such that infants in the Language at Test group performed more target actions after the 4-week delay relative to those in the Language at Encoding group. The results were interpreted as indicating that informative language provided at retrieval may serve as a better mnemonic cue than informative language presented only at encoding.

Finally, the influence of adult-provided linguistic support has also been demonstrated on the ability to generalize learned information across cues. This aspect of representational flexibility (Eichenbaum, 1997) allows individuals to apply learned information to various novel exemplars. Specifically, the ability to generalize learning across cues allows individuals to abstract important information about the functions of stimuli through their experiences with them and use that information when presented with new materials that are perceptually distinct from, but functionally equivalent to, those encountered previously. The ability to generalize across cues emerges during the second half of the first year of life (Lukowski, Wiebe, & Bauer, 2009) and continues to develop throughout the second year (Herbert & Hayne, 2000) and beyond, thereby demonstrating a similar developmental time course to what has been observed for recall memory (Carver & Bauer, 1999, 2001; Collie & Hayne, 1999; Bauer, Wenner, Dropik, & Wewerka, 2000). Despite their similar ontogenies, recall memory and generalization across cues are distinct but interrelated constructs: in one report, 16- and 20-month-olds generalized their learning to perceptually novel stimuli after a 1-week delay (Bauer & Dow, 1994; Experiment 1) but were also able to identify the specific stimuli that were presented to them before the 1-week delay (Bauer & Dow, 1994; Experiments 2 and 3). As such, generalization across cues does not result from the forgetting of sequence-specific information but instead results from the ability to flexibly apply acquired knowledge. Although both abilities are undoubtedly critical to human functioning, the ability to generalize learned information across cues is particularly important in that it ensures that we do not have to learn about the properties and functions of every newly-encountered object in the environment.

Only one study to our knowledge has examined the influence of supportive adult language on generalization across cues in preverbal infants. Herbert (2011) presented 12- and 15-month-olds with a three-step event sequence in one of two groups. Infants in the Full Narration group were presented with the sequence materials along with the name of the event and narration of the demonstrated actions at the first session; at the second session, these infants were provided with sequence materials that differed in form, but not color, from those shown at the first session along with a verbal reminder of the sequence name. Infants in the Empty Narration group were presented with the sequence materials and empty narration at the first session; at the second session, these infants were provided with sequence materials that differed in form, but not color, from those shown at the first session along with a general verbal prompt. The findings indicated that both groups of infants generalized their learning relative to a control group. Infants in the Full Narration group, however, produced more target actions after the 10-min delay relative to infants in the Empty Narration group. Taken together, these data suggest that adult-provided linguistic support not only facilitates recall of the particular events to which infants have been exposed, but may also be positively associated with the ability to flexibly apply learned information across cues.

In sum, the findings from the research conducted to date are clear: the language that adults use influences event memory in the second year of life and beyond. One potentially important (and heretofore unexamined) factor that may be associated with the extent to which preverbal infants and children benefit from adult-provided language is comprehension abilities. A limited literature documents associations between language comprehension and memory in infancy and early childhood. In one study, language comprehension at 14 months was concurrently associated with 8- to 10-min deferred imitation (Heimann et al., 2006). In another report, language comprehension was differentially associated with verbal and non-verbal memory for past events by 3- and 5-year-olds (McGuigan & Salmon, 2004). Language comprehension was positively associated with the amount of information correctly provided by 3-year-olds during free recall and in total (free recall plus cued recall), whereas language comprehension was only associated with picture sequencing, the included measure of non-verbal recall, by 5-year-olds (McGuigan & Salmon, 2004). Although these findings suggest that language comprehension is associated with recall in infants and children who are and who are not able to discuss the past using language, research has yet to be conducted to our knowledge to examine whether infant language comprehension moderates the extent to which preverbal infants use adult-provided language to structure their event memories.

The goal of the present research was to examine immediate imitation and 1-week delayed generalization across cues in 20-month-old infants as a function of (a) variability in adult-provided linguistic support at encoding and test, (b) infant language comprehension abilities, and (c) their interaction. To this end, we experimentally manipulated (1) adult-provided supportive language at encoding and (2) the supportiveness of the verbal prompt provided to cue delayed generalization at test; language comprehension was assessed using two parent-report measures. Twenty-month-olds were selected as participants because of the significant advances in language development that occur between 18 and 24 months of age (Fenson et al., 1994). We chose to examine generalization across cues instead of recall memory so as to further inform this limited literature by documenting associations among adult language use and infant language comprehension abilities on representational flexibility in the second year of life. Our hypotheses were as follows:

(a) Based on Hayne and Herbert (2004), we predicted that supportive adult language use at encoding would be unrelated to performance at immediate imitation (as they observed in Experiment 2A) and that the provision of supportive language at test would facilitate delayed generalization relative to an uninformative verbal prompt (as they observed in Experiment 2B). In one notable deviation from their work, we also predicted that supportive adult language use at encoding would be associated with delayed generalization across cues. We made this hypothesis based on research documenting the facilitating effect of encoding manipulations on delayed recall in infancy and early childhood (repeated exposures: Bauer, Wiebe, Waters, & Bangston, 2001; immediate imitation: Lukowski et al., 2005; immediate imitation and learning to criterion: Bauer, Güler, Starr, & Pathman, 2011).

(b) Based on previous research documenting positive associations between language comprehension and memory in preverbal infants on non-verbal memory assessments (Heimann et al., 2006) and in verbal children on verbal and non-verbal memory tests (McGuigan & Salmon, 2004), we predicted that infants with better language comprehension scores would demonstrate better encoding and delayed generalization across cues relative to infants with lower comprehension scores.

(c) Our novel contribution to the literature is in our expectation that infant language comprehension abilities would moderate the extent to which infants benefited from adult-provided supportive language at encoding and test. In particular, we predicted that language comprehension abilities would be positively associated with immediate imitation and 1-week delayed generalization across cues when the experimenter provided maximally supportive language at encoding (including narration of the sequence name and the three demonstrated actions) but not when minimally supportive language was used (including empty narration in place of the sequence name and the three demonstrated actions); we also anticipated associations between infant language comprehension abilities and delayed generalization across cues in relation to the supportiveness of adult-provided language at test.

2. Method

2.1. Participants

Twenty-five 20-month-old infants (mean age = 20 months, 4 days; range from 19 months, 16 days to 20 months, 15 days; 13 girls) participated. An additional four infants were recruited but did not complete the study (three families did not return for the second session and one parent did not complete the standardized language questionnaire); the data from two additional infants were excluded due to procedural errors.

Families were initially contacted through a mass mailing sent to parents who recently gave birth to an infant; parents who indicated an interest in participating provided the research team with their phone number and were later contacted with additional details about the study. All of the infants were born at term (40 ± 2 weeks gestation) and were experiencing an apparently typical course of development. Eighty percent of the infants were Caucasian, 8% were Asian, 4% were of mixed race; 8% of parents chose not to report race information. Forty-two percent of the infants were of Hispanic ethnicity. Seventy-six percent of mothers had earned at least a four-year college degree and 58% of families reported yearly incomes at or exceeding $75,000.

2.2. Materials and measures

2.2.1. Questionnaires

Parents completed a demographic questionnaire that inquired about infant race and ethnicity, parental education, and family income, among other things. Parents also indicated whether English was the primary language used in the home and reported the percent of the time their infant was exposed to English. In addition, parents completed two questionnaires pertaining to infant language development. General infant language comprehension was assessed using the MacArthur-Bates Communicative Development Inventory: Words and Gestures (MCDI; Fenson et al., 2007), a validated and standardized measure of parent-reported language comprehension and production. An additional language questionnaire was designed for use in this study (the Specific Language Questionnaire, SLQ) and asked parents to indicate whether their infant understood the sequence names and action phrases used by the experimenter when presenting the event sequences during elicited imitation testing (see Appendix B).

2.2.2. Elicited imitation

Six three-step event sequences were used in elicited imitation testing. Each event sequence was constrained by enabling relations, such that the three steps had to be completed in the correct temporal order for the sequence end-state to become apparent (although the sequences were constructed so that the three actions could be completed in any order). We chose to use sequences constrained by enabling relations so as to allow the infants the best opportunity to reproduce the demonstrated actions after the delay, as infants who are younger than 20 months commonly perform at chance when sequences are arbitrarily-ordered (Wenner & Bauer, 1999).

Each event sequence had an analog version that was perceptually distinct from, but functionally identical to, the original for the purposes of assessing delayed generalization across cues (Bauer & Dow, 1994; Bauer & Lukowski, 2010; Lukowski et al., 2009). The sequence forms differed in color and shape but not size or texture (an example sequence and its analog is shown in Fig. 1; verbal descriptions of the event sequences are provided in Appendix A). Different sequence forms were presented at each session but were counterbalanced across participants so that each version was used approximately equally as often at each session and in each sequence condition.

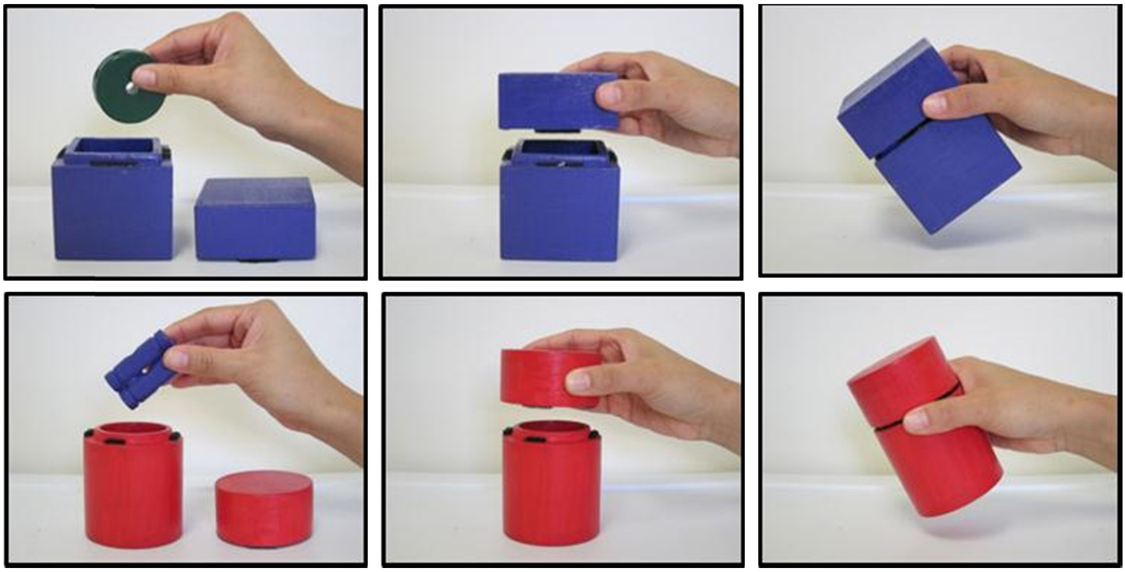

Fig. 1. Example of the three-step event sequence Make a Shaker. As described in Section 2, each event sequence was created in two forms that were perceptually distinct but functionally identical to one another. The left panels show the first step of putting the block into one of the wooden cups; the middle panels show the second step of assembling the wooden cups; the right panels show the third step of shaking the assembled apparatus (although infants also received credit for shaking only one of the wooden cups when the shaker was not fully assembled).

2.3. Procedure

The procedure was approved by the relevant institutional review boards; parents signed informed consent statements indicating their willingness to allow their infant to participate. Each session was video recorded to allow for periodic protocol checks and offline data coding. A table depicting the general procedure at both sessions is shown in Table 1.

2.3.1. Questionnaires

Parents received the demographic questionnaire by mail along with instructions to complete it at home and return it at the first session. Parents completed the MCDI at the first session as their infant participated in the elicited imitation assessment; parents who did not finish the questionnaire at that time were asked to complete it at home and return it at the second session. Parents completed the SLQ as their infant participated in the elicited imitation assessment at the second session; this questionnaire was not provided along with the MCDI at the first session to ensure that parents did not rehearse the sequence names and action phrases with their infant during the delay between the first and second sessions. Parents were instructed to complete both language questionnaires while only considering words and phrases that their infants comprehended in English.

2.3.2. Elicited imitation

Infants were tested by one of two female experimenters; infants interacted with the same experimenter at each session. The primary experimenter tested approximately 65% of the participants; approximately 50% of the infants tested by each experimenter were girls.

After the infant was seated across from the experimenter at an adult-sized table, the experimenter showed the infant how to roll a plastic ball on the table and place it inside of a metal Slinky twice in succession with narration; the infant was allowed the opportunity to imitate once the demonstrations were complete. This warm-up activity has been used in previous research (Bauer & Dow, 1994; Bauer et al., 1995, 2000; Bauer & Wewerka, 1995) to familiarize the infant both with the experimenter and with the turn-taking format of the elicited imitation procedure.

After the warm-up phase was complete, each infant was presented with six novel three-step event sequences in succession. During the baseline phase of testing, infants were presented with the props along with a general verbal prompt to

Table 1
General study design at each session.

Session	Baseline	Modeling (2×)	Immediate imitation	Modeling (1×)	General verbal prompt	Specific verbal prompt
1	A, B, C, D, E, F	A, B, C, D, E, F	A, B, C, D, E, F	A, B, C, D, E, F	–	–
2	–	–	–	–	A′, B′, C′, D′, E′, F′	A′, B′, C′, D′, E′, F′

Note: Infants were presented with different forms of the event sequences at the first and second sessions; the sequences presented at the second session were functionally identical to but differed perceptually from those used at the first session.

encourage interaction with the sequence materials ("What can you do with this stuff?"). The baseline phase ended when the infants engaged in repetitive or off-task behaviors, such as mouthing the props or banging them on the table (Bauer & Hertsgaard, 1993; Bauer et al., 2000). The experimenter then demonstrated how to complete each sequence of actions two times in succession with narration.

The primary experimental manipulation was the within-subjects condition to which the event sequences were assigned at the first session. Two sequences were presented in each of three conditions; the sequences were block randomized 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 infant 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 infant 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. Look at this. Watch here." 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, "Watch what I can make," as she set the props on the table. As she completed each of the three actions, she used language such as, "Check this out. See here. Watch this." 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 randomized across sequences in the moderately and minimally supportive conditions at the first session.

After each sequence was modeled by the experimenter, the infants were allowed an opportunity for immediate imitation as an index of encoding (Bauer, 2005; Bauer & Lukowski, 2010; Bauer et al., 2000, 2011; Hayne & Herbert, 2004; Herbert & Hayne, 2000); infants were provided with the same sequence materials as those used during baseline and sequence modeling. As the experimenter passed the sequence materials to the infants, she provided them with a general verbal prompt to encourage interaction with the sequence materials ("What can you do with this stuff?"). Infants interacted with the props until they engaged in the repetitive or off-task behaviors described previously. After the immediate imitation phase was complete, the experimenter demonstrated each event sequence once again using the same language and sequence materials as she did during the initial modeling phase (see Bauer & Lukowski, 2010).

Infants returned to the laboratory after approximately one week for an assessment of delayed generalization across cues (mean delay = 7 days; range from 6 days to 7 days). After a brief warm-up period, infants were presented with the analog versions of the six sequences that were shown at the first session. Delayed generalization was assessed for each sequence in turn using the procedure described in Bauer et al. (2000). Specifically, the experimenter placed the analog props on the table and pushed them toward the infant while providing a general verbal prompt to encourage interaction with the sequence materials ("What can you do with this stuff?"). When the infants engaged in repetitive or off-task behaviors, the experimenter provided the infant with the name of the event sequence ("You know what, you can use this stuff to Make a Shaker. How do you Make a Shaker with this stuff?") as an additional sequence-specific mnemonic cue. Infants were allowed to interact with the sequence materials until they again engaged in the repetitive or off-task behaviors described previously.

2.4. Data reduction

2.4.1. Questionnaires

The data from the language questionnaires were reduced to provide information about infant comprehension abilities. General language comprehension was computed from the MCDI by recording the number of vocabulary words parents indicated their infant understood (average number of comprehended words = 206, range from 9 to 364 words). Given our goal of examining relations between general language comprehension and mnemonic performance, we assigned infants into high (n = 13) and low (n = 12) comprehension groups using a median split (median = 237 words); the one infant whose comprehension score was on the median was assigned to the high comprehension group.[1] Data from the SLQ were reduced to determine the total number of sequence names (maximum possible = 2) and action phrases (maximum possible = 6) infants comprehended by condition. The data from the demographic questionnaire were reduced to provide information about the characteristics of the sample and to indicate whether infants in the high and low comprehension groups differed in any way.

2.4.2. Elicited imitation

The two experimenters were trained on data coding procedures before participant testing began using an existing corpus of data. The experimenters then coded the elicited imitation data online as it was being collected (Bauer et al., 2011; Bauer & Lukowski, 2010). The experimenters recorded both the occurrence of individual target actions and their order. Individual

[1] The reported between-subjects sample size is similar to others that have been used in this literature (see Brito & Barr, 2012; Hayne & Herbert, 2004).

target actions were coded when the infant completed any of the three actions previously modeled by the experimenter whereas temporal order information was coded by recording the order in which the infants completed the actions. As has been done in previous research, only the first occurrence of each behavior was coded so as to reduce the likelihood of obtaining credit for behaviors 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 25% of the sample ($n = 6$, including four infants tested by the primary experimenter and two infants tested by the secondary experimenter). Reliability values were acceptable for each pair of coders (reliability coder and primary experimenter: mean = 95%, range 87% to 100%; reliability coder and secondary experimenter: mean = 97%, range 95–98%).

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 1-week delay; total performance at the second session results from the additional facilitating effect of the verbal reminder (Bauer et al., 2000). We chose to analyze performance on both target actions and pairs of actions completed in the correct temporal order so as (1) to maintain consistency with the existing literature, which only documents associations between adult-provided linguistic support and the retention of individual target actions and (2) to examine an additional aspect of memory and generalization for which there is no information inherent in the sequence materials themselves, whereas the perceptual features of the presented props might serve to cue recall of individual target actions, there is no information in the materials themselves to cue the order in which the target actions must be completed to realize the sequence end-state (Bauer, 1997).

3. Results

3.1. Determination of potential covariates

We initially examined whether general language comprehension as assessed by the MCDI and comprehension of the sequence names and action phrases used during elicited imitation testing as assessed by the SLQ were associated with participant age, participant sex, maternal education, family income, or the percent of the time the infants were exposed to English, defined as exposure to English less than 50% of the time (=0) or at least 50% of the time (=1). The only consistent correlations indicated that exposure to English was positively associated with comprehension on the MCDI: $r(23) = .67$, $p < .0001$, and with comprehension of the action phrases used during elicited imitation testing: $r(23) = .71$, $p < .0001$.

Given the demonstrated association between exposure to English and language comprehension, we conducted a chi square analysis to determine whether the high and low comprehension groups differed in their distribution of infants who were exposed to English less than 50% of the time. The results indicated that a greater number of infants in the low comprehension group were exposed to English less than 50% of the time ($n = 5$; 42%) relative to the high comprehension group ($n = 1$; 8%); a greater number of infants in the high comprehension group was exposed to English at least 50% of the time ($n = 12$; 92%) relative to infants in the low comprehension group ($n = 7$; 58%): $\chi^2(1, N = 25) = 3.95$, $p < .05$. Taken together, these results indicate that general language comprehension scores were not associated with demographic characteristics other than the percent of the time participants were exposed to English. Given the significant relation between the percent of time infants were exposed to English and language comprehension in combination with our prediction that comprehension abilities would be associated with encoding and delayed generalization across cues, we included exposure to English as a covariate the following analyses. Results are presented when $p \leq .05$.

3.2. Elicited imitation

The elicited imitation data (means and standard errors of the mean) are shown in Table 2 controlling for infant exposure to English.

3.2.1. Immediate imitation

Two 2 (group: high or low language comprehension) × 3 (condition: maximally, moderately, and minimally supportive) × 2 (phase: baseline and immediate imitation) mixed ANCOVAs were conducted on target actions and pairs of actions completed in the correct temporal order controlling for exposure to English.

Main effects of phase were found for both target actions: $F(1, 22) = 26.03$, $p < .0001$, $\eta_p^2 = .54$, and pairs of actions completed in the correct temporal order: $F(1, 22) = 24.00$, $p < .0001$, $\eta_p^2 = .52$, such that performance at immediate imitation exceeded that at baseline. As shown in Fig. 2, the main effects of phase were further qualified by interactions with group for both target actions: $F(1, 22) = 4.78$, $p < .04$, $\eta_p^2 = .18$, and pairs of actions completed in the correct temporal order: $F(1, 22) = 7.28$, $p < .02$, $\eta_p^2 = .25$. Follow-up pairwise comparisons conducted by group indicated that infants in both groups produced more target actions and pairs of actions at immediate imitation relative to baseline (all $ps < .0001$). Follow-up pairwise comparisons conducted by phase indicated that infants in the high comprehension group performed more pairs of actions ($p < .03$) at immediate imitation relative to infants in the low comprehension group; group differences in performance were not found on target actions at immediate imitation or on either dependent measure at baseline.

3.2.2. Delayed generalization

Two 2 (group: high or low language comprehension) × 3 (condition: maximally, moderately, and minimally supportive) × 3 (phase: baseline, before the provision of the specific verbal reminder, and total performance at the second session) mixed ANCOVAs were conducted on target actions and pairs of actions completed in the correct temporal order controlling for exposure to English.

Main effects of phase were found for both target actions: $F(2, 44) = 24.14$, $p < .0001$, $\eta_p^2 = .52$, and pairs of actions completed in the correct temporal order: $F(2, 44) = 20.46$, $p < .0001$, $\eta_p^2 = .48$. Additional pairwise comparisons conducted to identify the locus of the effect revealed differences across all phases on both dependent measures: infants performed more target actions and pairs of actions before the provision of the specific verbal reminder in total at the second session relative to baseline; infants also completed more target actions and pairs of actions in total at the second session relative to before the provision of the specific verbal reminder (all $ps < .0001$).

As is shown in Fig. 3, the main effects of phase were further qualified by interactions with group for both target actions: $F(2, 44) = 4.43$, $p < .02$, $\eta_p^2 = .17$, and pairs of actions completed in the correct temporal order: $F(2, 44) = 4.44$, $p < .02$, $\eta_p^2 = .17$. Follow-up pairwise comparisons conducted by group revealed significant main effects of phase for infants in both groups on both dependent measures ($ps < .004$, $\eta_p^2 s = .39–.69$). Infants performed more target actions

Table 2
Elicited imitation performance by group, condition, and phase controlling for infant exposure to English (means and standard errors).

Panel A: target actions

	Sequence condition			
	Maximally supportive	Moderately supportive	Minimally supportive	Overall (across conditions)
High comprehension group				
Baseline	.99 ± .14	.64 ± .14	.72 ± .12	.78 ± .10
Immediate imitation	2.40 ± .18	2.12 ± .27	2.28 ± .22	2.27 ± .06
Before specific prompt	2.14 ± .17	1.92 ± .18	1.45 ± .15	1.84 ± .10
Overall performance	2.29 ± .17	2.21 ± .18	1.98 ± .17	2.16 ± .13
Low comprehension group				
Baseline	.84 ± .15	.77 ± .14	1.01 ± .13	.87 ± .10
Immediate imitation	1.86 ± .18	1.83 ± .28	1.70 ± .23	1.80 ± .17
Before specific prompt	1.52 ± .18	1.55 ± .18	1.59 ± .15	1.55 ± .11
Overall performance	1.94 ± .18	1.65 ± .19	1.65 ± .18	1.74 ± .14
Overall (across groups)				
Baseline	.92 ± .10	.70 ± .09	.86 ± .09	.82 ± .06
Immediate imitation	2.14 ± .13	1.98 ± .18	2.00 ± .16	2.04 ± .12
Before specific prompt	1.84 ± .13	1.74 ± .12	1.52 ± .10	1.70 ± .08
Overall performance	2.12 ± .12	1.94 ± .13	1.82 ± .12	1.96 ± .10

Panel B: pairs of actions completed in the correct temporal order

	Sequence condition			
	Maximally supportive	Moderately supportive	Minimally supportive	Overall (across conditions)
High comprehension group				
Baseline	.25 ± .09	.07 ± .07	.10 ± .07	.14 ± .04
Immediate imitation	1.22 ± .17	1.24 ± .19	1.27 ± .18	1.25 ± .13
Before specific prompt	1.02 ± .15	.97 ± .14	.55 ± .15	.85 ± .08
Overall performance	1.14 ± .13	1.20 ± .14	.77 ± .17	1.03 ± .10
Low comprehension group				
Baseline	.23 ± .09	.21 ± .07	.19 ± .07	.21 ± .04
Immediate imitation	.80 ± .18	.78 ± .19	.83 ± .19	.80 ± .13
Before specific prompt	.56 ± .16	.58 ± .15	.73 ± .15	.62 ± .09
Overall performance	.93 ± .14	.62 ± .15	.80 ± .18	.78 ± .10
Overall (across groups)				
Baseline	.24 ± .06	.14 ± .05	.14 ± .05	.17 ± .02
Immediate imitation	1.02 ± .12	1.02 ± .13	1.06 ± .13	1.03 ± .09
Before specific prompt	.80 ± .11	.78 ± .10	.64 ± .10	.74 ± .06
Overall performance	1.04 ± .09	.92 ± .11	.78 ± .11	.91 ± .07

and pairs of actions before the provision of the specific verbal reminder in total at the second session relative to baseline; infants also completed more target actions and pairs of actions in total at the second session relative to before the provision of the specific verbal reminder (all *p*s $< .03$). Follow-up pairwise comparisons conducted by phase indicated that performance did not differ by group at baseline or before the provision of the specific verbal reminder on either dependent measure. However, infants in the high comprehension group generalized more target actions in total at the second session relative to infants in the low comprehension group ($p \leq .05$); total performance on pairs of actions did not differ by group.

Main effects of condition were also found for both target actions: $F(2, 44) = 8.37$, $p < .001$, $\eta_p^2 = .28$, and pairs of actions completed in the correct temporal order: $F(2, 44) = 4.30$, $p < .02$, $\eta_p^2 = .16$. Additional pairwise comparisons conducted to identify the locus of the effect within the three levels of condition only revealed significant effects for target actions, such that performance in the maximally supportive condition exceeded that in the minimally supportive condition ($p < .04$); performance in the moderately supportive condition did not differ from that in the maximally or minimally supportive conditions.

The aforementioned effects were further qualified by a three-way interaction among group, condition, and phase for pairs of actions completed in the correct temporal order: $F(4, 88) = 2.42$, $p \leq .05$, $\eta_p^2 = .10$. Although follow-up simple effects analyses were conducted by each of the included independent variables, we only present the analyses conducted by condition (additional information on the other simple effects analyses can be obtained from the last author). Analyses revealed significant main effects of phase for each condition (all *p*s $< .01$; η_p^2s $= .18–.40$); follow-up pairwise comparisons indicated that in each condition, infants performed more pairs of actions before the provision of the specific verbal reminder in total at the second session relative to baseline; infants also produced more pairs of actions in total at the second session relative to before the provision of the specific verbal reminder (all *p*s $< .01$). A significant Group × Phase interaction was also obtained for sequences presented in the minimally supportive condition: $F(2, 44) = 3.98$, $p < .03$, $\eta_p^2 = .15$, although follow-up pairwise comparisons did not reveal any significant differences between the means.

3.3. Continuous relations among language comprehension and elicited imitation performance

Pearson's correlations were conducted controlling for infant exposure to English to examine associations between language comprehension, encoding, and delayed generalization; these data are shown in Table 3. The elicited imitation data from the baseline assessment and parent-report of infant comprehension on the MCDI and SLQ are shown in Panel A. The elicited imitation and language comprehension data are collapsed across condition, as there were no procedural or performance differences by condition at baseline. Correlations examining immediate imitation and delayed generalization performance in relation to language comprehension are shown in Panel B. The complete set of correlations is shown for sequences presented in the maximally supportive condition, as infants 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 infants were

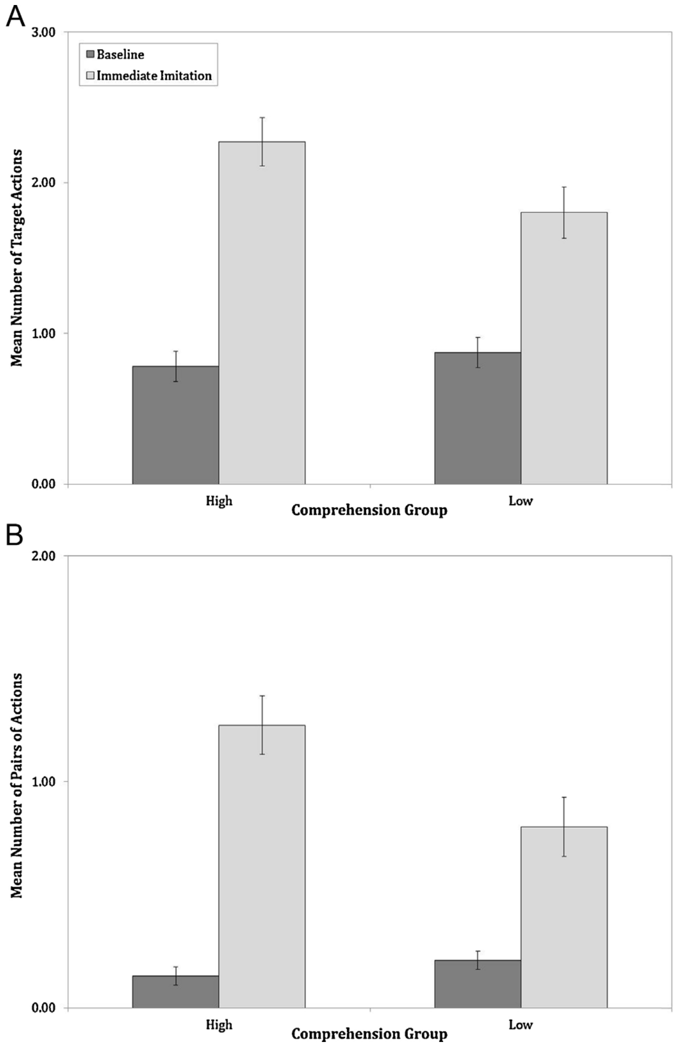

Fig. 2. Panel A: Group × Phase interaction for target actions at baseline and immediate imitation (means ± standard errors). Panel B: Group × Phase interaction for pairs of actions completed in the correct temporal order at baseline and immediate imitation (means ± standard errors).

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 generalization, as sequence names were only provided to participants when the specific verbal reminders were given 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.

3.3.1. Baseline

There were no significant associations between language comprehension on the MCDI or the SLQ and performance on the elicited imitation assessment at baseline.

3.3.2. Immediate imitation

General language comprehension as assessed by the MCDI was positively related to the production of target actions on sequences presented in the maximally supportive condition and to the production of pairs of actions on sequences presented in the maximally and moderately supportive conditions; comprehension of the sequence names on the SLQ was also positively associated with the production of target actions on sequences presented in the maximally supportive condition. Correlations between language comprehension and immediate imitation were not found for sequences presented in the minimally supportive condition.

3.3.3. Delayed generalization

When considering performance before the provision of the specific verbal reminder, general language comprehension on the MCDI and comprehension of the sequence-specific action phrases on the SLQ were positively associated with the production of target actions and pairs of actions on sequences presented in the maximally supportive condition. Correlations between language comprehension and delayed generalization before the provision of the specific verbal reminder were not found for sequences presented in the moderately and minimally supportive conditions.

A different pattern of relations was apparent when considering total performance at the second session. Comprehension of the sequence names and action phrases on the SLQ was positively associated with the production of target actions and pairs of actions on sequences presented in the maximally supportive condition. One additional correlation indicated that general language comprehension on the MCDI was positively related to the production of

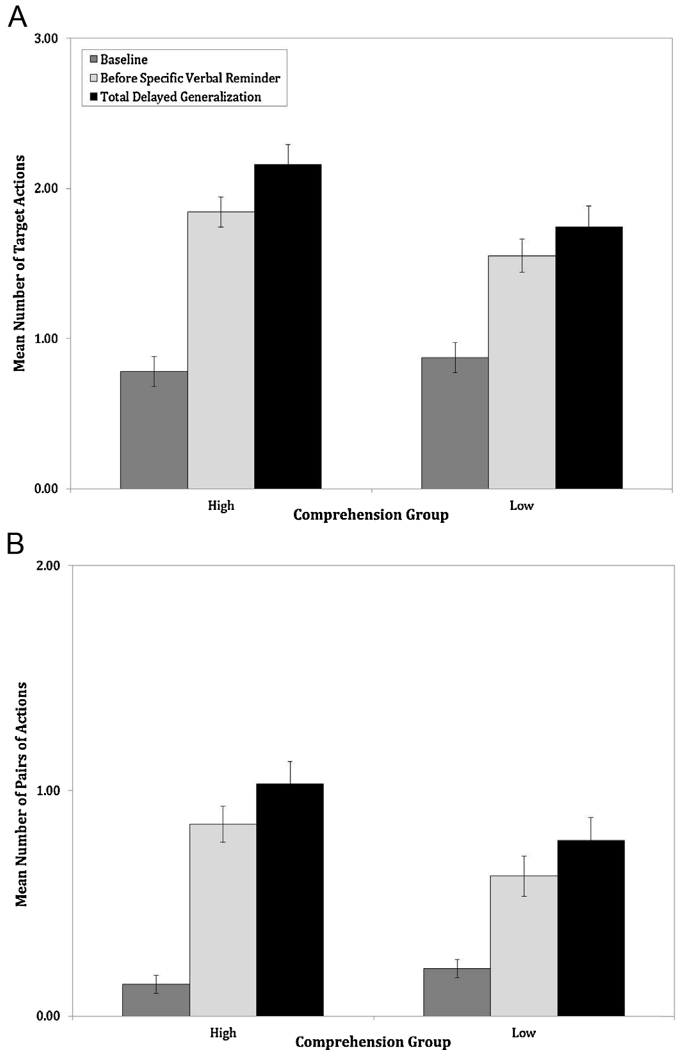

Fig. 3. Panel A: Group × Phase interaction for target actions at baseline, before the provision of the specific verbal reminder, and in total at the second session (means ± standard errors). Panel B: Group × Phase interaction for pairs of actions completed in the correct temporal order at baseline, before the provision of the specific verbal reminder, and in total at the second session (means ± standard errors).

pairs of actions completed in the correct temporal order on sequences presented in the moderately supportive condition. Correlations between language comprehension and total delayed generalization were not found for sequences presented in the minimally supportive condition.

4. Discussion

The goal of the present research was to examine immediate imitation and 1-week delayed generalization across cues in 20-month-old infants as a function of (a) variability in adult-provided linguistic support at encoding and test, (b) infant language comprehension abilities, and (c) their interaction. Analyses indicated that infants imitated the actions immediately after their demonstration regardless of comprehension group or sequence condition; they also generalized their learning of both target actions and pairs of actions after the 1-week delay. Additional findings revealed that adult language use and infant comprehension abilities were differentially associated with immediate imitation and 1-week delayed generalization across cues as well as interacted with one another to facilitate encoding and delayed generalization when the most supportive adult language was provided at encoding and test.

As described in Section 3, the findings confirmed our hypotheses. Variability in adult-provided supportive language at encoding was not associated with performance at immediate imitation but instead influenced 1-week delayed generalization across cues. In particular, infants generalized a greater number of target actions on sequences presented in the maximally supportive condition relative to the minimally supportive condition; no difference in performance was observed on when considering total performance at the second session relative to performance before the provision of the specific verbal reminder or on pairs of actions completed in the correct temporal order.

Table 3
Pearson's correlations between language comprehension and elicited imitation performance controlling for infant exposure to English.

Panel A: elicited imitation performance at baseline

	Target actions	Pairs of actions
MCDI comprehension	−.21	−.18
SLQ sequence names	−.07	−.02
SLQ action phrases	−.16	−.09

Panel B: elicited imitation performance at immediate imitation and delayed generalization

	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	.51*	.50*	.38	.49*	.28	.26
SLQ sequence names	.45*	.34	.09	.06	.46*	.41*
SLQ action phrases	.39	.28	.13	.33	.39	.37
Before the provision of the specific verbal reminder at the second session						
MCDI comprehension	.42*	.42*	.27	.40	−.26	−.27
SLQ sequence names	.11	.10	.05	.03	−.10	−.09
SLQ action phrases	.53*	.43*	.25	.27	.11	−.03
Total delayed generalization performance at the second session						
MCDI comprehension	.12	.10	.33	.51*	.03	−.18
SLQ sequence names	.50*	.57*	−.03	−.04	−.06	−.14
SLQ action phrases	.44*	.42*	.21	.26	−.01	−.14

Note: None of the correlations presented in Panel A are statistically significant.
* $p \leq .05$.

Taken together, these findings indicate that adult-provided supportive language at encoding facilitated delayed generalization to a greater extent than supportive language used only at test. We expected this outcome based on previous research documenting the beneficial effect of encoding manipulations on recall memory in infancy and early childhood (repeated exposures: Bauer et al., 2001; immediate imitation: Lukowski et al., 2005; immediate imitation and learning to criterion: Bauer et al., 2011), although this prediction would have been unwarranted based on the findings reported by Hayne and Herbert (2004; Experiment 2B). In their research, infants in the Language at Test group recalled more target actions relative to infants in the Language at Encoding group, suggesting that supportive adult language used at test served as a more effective retrieval cue than supportive language at encoding. Although procedural dissimilarities may account for the different findings across our studies, other possibilities exist. One possibility is that infants in the Language at Encoding group forgot the informative language that was provided to them at the first session during the 4-week delay. If that were the case, infants in the Language at Encoding group would be expected to perform similarly to infants in an Empty Narration condition, in which no supportive language was provided at either encoding or test. Review of the data presented in Experiments 1 and 2B of Hayne and Herbert (2004) supports this possibility, such that infants in the Language at Encoding group in Experiment 2B performed nominally less well than infants of the same age tested over the same delay in the Empty Narration condition of Experiment 1 ($.67 \pm .16$ and $.80 \pm .17$, respectively). Another possibility is that supportive language at test facilitated recall because infants in the Language at Test group understood the sequence names provided by the experimenter and used their previous knowledge to scaffold their performance, allowing them to successfully deduce the necessary target actions. The correlational data we collected suggest this option is unlikely, however, as comprehension of the sequence names was unrelated to total delayed generalization on events presented in the minimally supportive condition in our study (this condition is conceptually similar to the Language at Test group in Hayne & Herbert, 2004).

Other analyses indicate that language comprehension was associated with immediate imitation and delayed generalization across cues. Infants in the high comprehension group performed more pairs of actions at immediate imitation relative to infants in the low comprehension group. Similarly, infants in the high comprehension group generalized more target actions in total after the 1-week delay relative to infants in the low comprehension group; group differences in performance were not found at baseline or before the provision of the specific verbal reminder. Taken together, these findings suggest that infants in the high comprehension group may be more attuned to the language used by the experimenter at the first session, ultimately resulting in better performance at immediate imitation and after the 1-week delay as well. Indeed, infants in the high comprehension group were better able to use the supportive adult language provided at test to scaffold their performance on target actions relative to infants in the low comprehension group, whereas group differences were not apparent before the provision of the specific verbal reminder at the second session.

One alternative explanation for the obtained associations between language comprehension and mnemonic performance is that infants in the high comprehension group outperformed infants in the low comprehension group because the former group of infants was more cognitively competent than the latter. Indeed, previous research has demonstrated that early language comprehension is positively associated with later intelligence (Bornstein & Hayes, 1998; Rose, Feldman, & Wallace, 1991). We believe that differential early intelligence does not account for our findings for the following reasons. (1) Infants in the high and low comprehension groups did not differ in their performance of target actions or pairs of actions at baseline, which would have been expected if they were differentially able to deduce the dependent measures through trial-and-error problem-solving efforts. (2) Infants in the high and low comprehension groups did not differ on demographic characteristics that have demonstrated associations with infant intelligence in other research, including maternal education and socio-economic status (Bornstein & Hayes, 1998). (3) Forty-two percent of the infants in the low comprehension group were exposed to English less than 50% of the time whereas only 8% of the infants in the high comprehension group were similarly exposed to English. These arguments indicate that infants in the high and low comprehension groups differed primarily in their early exposure to and comprehension of English and were likely similar in general cognitive ability.

Our final prediction was that infant language comprehension abilities would moderate the extent to which infants benefited from adult-provided supportive language at encoding and test. In particular, we expected that infant language comprehension would be positively associated with immediate imitation and 1-week delayed generalization across cues when the experimenter provided maximally supportive language at encoding but not when minimally supportive language was used. Analyses of variance revealed a significant three-way interaction among group, condition, and phase when considering delayed generalization across cues, although follow-up simple effects analyses and pairwise comparisons did not yield any additional information about the locus of the effect. Correlations were more informative in this regard, they indicated that infant language comprehension abilities were significantly associated with immediate imitation and 1-week delayed generalization across cues but also varied in relation to the provision of supportive adult language at encoding and test. In particular, infant language comprehension was associated with performance at immediate imitation and delayed generalization on sequences presented in the maximally and moderately supportive conditions but not with those presented in the minimally supportive condition. The pattern of correlations for sequences presented in the maximally supportive condition in particular suggests that whereas general language comprehension may be associated with better performance at immediate imitation, understanding the sequence-specific information presented at encoding is associated with better delayed generalization at the second session. As evidence of this, comprehension of the sequence-specific action phrases–which were only presented at encoding for sequences in the maximally supportive condition–was associated with delayed generalization performance both before the provision of the specific verbal reminder and in total at the second session. These data suggest that greater adult-provided linguistic support at encoding, in combination with better language comprehension abilities, allowed for greater ability to flexibly apply learned information across cues. As Brito and Barr (2012) suggested in their recent report, infants with better comprehension abilities may also be better able to establish relations between the various elements of the event, ultimately allowing for enhanced generalization abilities. Additional research should be conducted using visual paired comparison or eye-tracking technology to determine whether those infants who actively map sequence-specific narration onto the props and actions used during modeling are those who also successfully recall and generalize their learning over lengthy delays. Indeed, previous research has established that variability in both encoding (Bauer & Dow, 1994; Bauer, Wiebe, Carver, Waters, & Nelson, 2006) and consolidation and storage processes (Bauer, 2005; Bauer, Wiebe, Carver, Waters, & Nelson, 2003; DeBoer, Wewerka, Bauer, Georgieff, & Nelson, 2005) are associated with later recall performance (see Bauer, 2006, for a review).

Additional studies on language-cognition relations in infancy and early childhood should also account for the limitations of the present research. The primary limitation of this work is that infant comprehension was determined based on parent-reported abilities. The MCDI was developed with the limitations of parent-report measures in mind, such that parents only report on the current behaviors demonstrated by the infant and do so using a recognition- rather than recall-based format (Stiles, 1994). As a result, these questionnaires are widely regarded as the gold standard parent-report measure of early language development. The SLQ was similarly designed such that parents were only asked to recognize which of the sequence names and action phrases their infant comprehended at the second session. Nevertheless, future researchers should include additional measures to ensure the accuracy of parent report, such as by having parents report confidence ratings or by confirming parent-reported comprehension through behavior (Mills, Coffey-Corina, & Neville, 1997).

One additional direction for future research is to examine associations between adult-provided linguistic support and infant language comprehension in infants who are homogenously monolingual or bilingual, given previous findings documenting positive associations between bilingualism and delayed generalization across cues in the absence of any adult-provided supportive language (Brito & Barr, 2012). Although we were unable to classify our sample as monolingual or bilingual as done by Brito and Barr (2012), the majority of infants who were exposed to English less than 50% of the time were placed into the low comprehension group. We suggest that our grouping of participants was a strength in the present research, however, given that low comprehension scores likely resulted from reduced familiarity with English rather than an as-of-yet-unidentified cognitive deficit. Moreover, our data indicate that neither the high nor the low comprehension groups was comprised entirely of infants who were exposed to English (a) at least 50% of the time or (b) less than 50% of the time, suggesting that exposure to a language other than English did not preclude the possibility of high English comprehension scores. Finally, the diversity of our sample likely allows for findings that are more broadly applicable and generalizable than those collected from infants with more restricted linguistic backgrounds. For these reasons, we suggest that our grouping of the participants effectively indicates that infant comprehension of English is associated with immediate imitation and delayed generalization across cues when adults provide supportive language in English; future research is required to see whether monolingual and bilingual infants differentially benefit from adult-provided supportive language in this and other contexts.

The strengths of the conducted research significantly outweigh this limitation, however. Through the use of a unique within-subjects design, we examined immediate imitation and 1-week delayed generalization across cues in 20-month-old infants as a function of (a) variability in adult-provided linguistic support at encoding and test, (b) infant language comprehension abilities, and (c) their interaction. The findings contribute to the literature by demonstrating that adult language use and infant language comprehension are independently and differentially associated with immediate imitation and 1-week delayed generalization across cues but also serve to jointly structure event memory in the second year of life. In particular, infant language comprehension abilities were associated with the encoding of information independent of adult-provided linguistic support, whereas 1-week delayed generalization was multiply determined through infant language comprehension and adult-provided linguistic support. These data suggest that the provision of supportive language by parents and educators may facilitate the flexible application of knowledge in early childhood, ultimately enriching infants' developing understanding of the world in which they live.

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Appendix A. Description of the six event sequences and their analog forms

Play with Tools (a wooden base with two hinged flaps that can be lifted to form a support; a wooden slab with a hole cut in the center; a round peg that fits snugly within the hole in the wooden slab; a hammer). To complete the event sequence, one must: (1) lift up the hinged flaps to form a support; (2) place the wooden slab on top of the established support; (3) use the hammer to pound the peg. The two versions of the event differed in the color of each item as well as shape of the wooden base, the shape of the wooden slab, and the shape of the hammer.

Make a Dancing Toy (a wooden based with a hole in the center; a wooden stick with Velcro attached to one end; a commercially-available jumping jack toy with a piece of Velcro attached to the top). To complete the event sequence, one must: (1) put the end of the wooden stick without the Velcro into the base; (2) attach the jumping jack toy to the end of the stick using the Velcro on both pieces; (3) pull the string on the jumping jack toy. The two versions of the event differed in the color of each item as well as the shape of the wooden stick, the shape of the wooden base, and the jumping jack toy used (a clown or a lion).

Make a Gong (a wooden base with two supports; a wooden bar that fit across the supports; a metal plate to be hung from the wood bar; a hammer). To complete the event sequence, one must: (1) place the bar across the supports; (2) place the metal plate on the bar; (3) use the hammer to ring the plate. The two versions of the event differed in the color of each item as well as shape of the wooden base, the shape of the metal plate, and the shape of the hammer.

Play the Drum (a hollow wooden based with a notch cut into the edge; an L-shaped wooden rod; a wood-encased metal lid). To complete the event sequence, one must: (1) place the L-shaped wooden rod into the notch on the base; (2) place the wood-encased metal lid on the base; (3) press the rod so that the L-shaped portion makes contact with the metal on the lid. The two versions of the event differed in the color of each item as well as shape of the wooden base and the shape of the wood-encased metal lid.

Make a Spinner (a wooden base with one fixed vertical side and one hinged side that can be lifted to form a support; a wooden rod with a shape affixed to the center). To complete the event sequence, one must: (1) lift the hinged side of the base to form a support; (2) place the wooden rod onto the support; (3) spin the shape affixed to the center of the rod. The two versions of the event differed in the color of each item as well as the details of the supports and the shapes affixed to the center of the rods.

Make a Shaker (two wooden cups; a small wooden block). To complete the event sequence, one must: (1) Put the block into one of the cups; (2) cover one cup with the other; (3) shake the assembled apparatus. The two versions of the event differed in the color of each item as well as the shape of the cups and the shape of the wooden block.

Appendix B. Specific Language Questionnaire (SLQ)

Please read the following words and phrases and check the boxes associated with words or phrases that your child seems to understand.

- ☐ Play with tools.
- ☐ Open it up.
- ☐ Put it on top.
- ☐ Pound it.
- ☐ Play the drum.
- ☐ Put in the paddle.
- ☐ Put on the lid.
- ☐ Push it.

- ☐ Make a dancing toy.
- ☐ Put in the stick.
- ☐ Hang it up.
- ☐ Pull it.
- ☐ Make a spinner.
- ☐ Lift it up.
- ☐ Put it on here.
- ☐ Spin it.

- ☐ Make a gong.
- ☐ Swing it over.
- ☐ Put on the plate.
- ☐ Ring it.
- ☐ Make a shaker.
- ☐ Put in the block.
- ☐ Cover it up.
- ☐ Shake it.

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