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Fast Mapping and Word Learning by Preschoolers with SLI in a Supported Learning Context: Effect of Encoding Cues, Phonotactic Probability and Object Familiarity

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Abstract

Purpose—This study investigated whether phonological or semantic encoding cues improved the fast mapping or word learning performance of preschoolers with specific language impairment (SLI) or typical development (TD) and whether performance varied for words containing high- or low-frequency sublexical sequences that named familiar or unfamiliar objects.

Method—Forty-two preschoolers with SLI, 42 preschoolers with TD matched for age and gender to children with SLI, and 41 preschoolers with TD matched for expressive vocabulary and gender to children with SLI learned words in a supported learning context. Fast mapping, word learning, and post-task performance were assessed.

Results—Encoding cues had no effect on fast mapping performance for any group, nor on the number of words children learned to comprehend. Encoding cues appeared to be detrimental to word production for children with TD. Across groups a clear learning advantage was observed for words with low-frequency sequences and to a lesser extent, words associated with an unfamiliar object.

Conclusions—Results suggest that phonotactic probability and previous lexical knowledge affect word learning in similar ways for children with TD and SLI and that encoding cues were not beneficial for any group.

A significant proportion of children with specific language impairment (SLI) have difficulty learning new words (Ellis Weismer & Hesketh, 1998; Horohov & Oetting, 2004; Kiernan & Gray, 1998; Gray, 2004, 2005, 2006; Nash & Donaldson, 2005; Rice, Buhr, & Oetting, 1992; Rice, Oetting, Marquis, Bode, & Pae, 1994). This may affect other important areas of development including listening (Florit, Roch, Altoe & Levorato, 2009) and reading comprehension (Bishop & Adams, 2006; Cunningham & Stanovich, 1997; Scarborough, 2001; Storch & Whitehurst, 2002). A growing body of research suggests that poor word learning by children with SLI is related to difficulty creating and storing phonological and semantic representations of new words and establishing a strong link between those representations (Alt & Plante, 2006; Gathercole, Hitch, Service & Martin, 1997; Gray, 2005; McGregor, Friedman, Reilly & Newman, 2002; Storkel, 2001, 2003). These results are apparent in both fast mapping and slow mapping word learning studies.

Fast mapping is the earliest stage of word learning when a child is exposed to a new word the first few times (Carey, 1978). Previous studies investigating children's ability to fast map

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a lexical label to a novel referent have shown that preschoolers with language impairment may comprehend as well as their peers with typical development (TD) in fast mapping comprehension tasks (Dollaghan, 1987; Gray, 2003, 2005), but they may (Gray, 2003, 2004, 2005) or may not (Dollaghan, 1987) demonstrate fast mapping production comparable to their peers with TD. In fast-mapping studies investigating preschoolers' ability to map lexical labels *and semantic features* to novel objects and actions, Alt, Plante and Creusere (2004) and Alt and Plante (2006) found that SLI groups were significantly less accurate than age-matched groups on comprehension tasks. The characteristics of words and referents and the nature of the tasks varied considerably among these studies, but it is clear that a number of children with SLI have difficulty fast mapping.

During fast mapping a child must map a sufficient amount of phonological and semantic information to elaborate a new word when they hear it again. This is followed by the ‘slow mapping’ stage of word learning (Carey, 1978). During this stage, with repeated exposures, the child develops more robust phonological, lexical, and semantic representations of the word and the links between representations are strengthened (McGregor, Friedman, Reilly & Newman, 2002). Research suggests that children with language impairment require more exposures to a word to comprehend or to produce it than their peers with TD (e.g. Ellis Weismer & Hesketh, 1998; Gray, 2004; Rice, Oetting, Marquis, Bode & Pae, 1994), resulting in a slower word learning process. Thus, children with SLI learn new words, but they often require more exposures than their peers with TD to do so (Gray, 2003). Unfortunately, given busy classroom and home environments, it is unlikely that children will receive increased exposures to all of the higher level vocabulary words that are critical for academic success. Therefore, word learning *efficiency* is an important target for intervention.

Although many studies have investigated the nature of word learning deficits in SLI groups, relatively few have investigated interventions to improve word learning. Broadly speaking, two approaches have been studied. The first involves reducing cognitive processing demands based on the hypothesis that children with SLI have reduced cognitive processing capacity (Hoffman & Gillam, 2004; Montgomery, 2002). Ellis Weismer (1997) and Ellis Weismer and Hesketh (1998) used emphatic stress on novel words to focus children's attention so that cognitive processing capacity could be freed to process new linguistic information. They found that school-aged children with TD and SLI learned to produce more words if they were modeled with emphatic rather than neutral stress. In another study intended to reduce cognitive processing demands, Horohov and Oetting (2004) found that school-aged children with SLI comprehended new words better when they were presented in a videotaped story read at a slower vs. faster rate, but that reading rate did not affect new word comprehension in children with TD.

The second intervention approach addresses specific components of working memory rather than overall working memory capacity. To produce new words children must develop phonological, lexical, and semantic representation and link them (e.g. Caramazza, 1997; Gupta & MacWhinney, 1997). Phonological representations specify the individual sounds in words, lexical representations specify the phonological form of the whole word, and semantic representations specify the meaning. Lexical representations must be sufficiently differentiated to allow the child to recognize a new word when they hear it, thereby initiating storage of the new word's phonological, lexical and semantic representations. If the quality of the phonological representation is poor, this can preclude recognition of the word when it is encountered again and prevent elaboration of the stored word.

Several studies have sought to improve word learning by children with TD or SLI by strengthening the phonological or semantic representations of the new words. In their study of 8-year-olds with TD, McGregor, Sheng and Ball (2007) found that a higher number of exposures (n=32) within three weekly teaching sessions resulted in better word naming and defining than a lower number (n=16) of exposures. In addition, higher context informativeness, manipulated through the use of pictures alone or pictures plus a verbal definition during teaching, resulted in higher production of accurate information units and semantic attributes when children defined new words.

Demke, Graham and Siakaluk (2002) aimed to help preschoolers with TD maintain phonological representations of novel words in working memory. They presented new words in two story context conditions: (a) providing a rhyming word immediately before the target word or (b) providing a rhyming word immediately after the target word. There was no effect when the rhyming word preceded the target; however, the majority of children who heard the rhyme after the target produced the novel label on their first try and in successive attempts, whereas significantly fewer children in the control condition, who did not hear the rhyming word, were able to do so. The authors concluded that exposure to phonological neighbors after hearing a new word helped maintain that word's phonological representation in working memory and that this may have promoted the formation of ‘more durable long-term representations of the new words’ (p. 389).

Gray (2005) manipulated phonological and semantic encoding cues during word learning to determine whether either cue type improved word learning by preschoolers with TD or SLI. The hypothesis was that phonological encoding cues would help create stronger phonological representations and semantic encoding cues would help create stronger semantic representations. For comprehension, the number of words learned did not differ by cue type for the TD group; however, the SLI group learned to comprehend more words in the semantic than phonological condition. Production results were similar to comprehension results for the TD group, who did not differ by condition; but the SLI group learned to produce significantly more words in the phonological than semantic condition.

Results of Gray (2005) suggested that children with SLI benefitted from encoding cues; however, there were several limitations to the study. First, the phonological and semantic cueing conditions were not compared to a no-cue condition, which potentially could be superior to the cued conditions. Second, encoding cues were presented during the word learning portion of the study, but not during the fast-mapping portion. Because fast mapping performance contributes significantly to later word learning (Gray, 2003), cues presented during this stage could have an additional benefit. Third, the words children learned were not selected based on phonotactic probability (PP) or neighborhood density (ND), which have subsequently been shown to influence word learning in children with TD (Storkel, 2001, 2003, 2004; Storkel & Maekawa, 2005; Storkel & Rogers, 2000). Finally, the performance of children with SLI was compared to children with TD matched for age- and gender to children with SLI. By adding a vocabulary-matched group, it would be possible to assess whether the effects of encoding cues might differ depending on vocabulary size or language ability. Therefore, the first purpose of this study was to determine whether phonological or semantic encoding cues, presented immediately after a new word was modeled, would improve the word learning efficiency of the SLI group compared to the age- and gender-matched TD group and the (younger) vocabulary- and gender-matched TD group. The specific research questions were:

1. Do phonological or semantic cues result in better fast mapping comprehension or production than no cues and does this differ by group?
2. Do phonological or encoding cues increase the number of words children learn to comprehend or produce relative to the no-cue condition and does this differ by group?

3 Do phonological or semantic encoding cues reduce the number of trials needed to comprehend or produce a new word relative to the no-cue condition and does this differ by group?

4 Do phonological or semantic cues result in higher post-task performance than the no-cue condition as measured by comprehension or production measures and does this differ by group?

We hypothesized that the encoding cues could improve fast mapping and word learning in several ways. First, children would be encouraged to attend to important phonological characteristics of the words or semantic characteristics of the target objects beginning with the first exposure. Potentially this could reduce the need for children to deduce these important characteristics on their own. Second, we hypothesized that semantic encoding cues would activate related concepts in semantic memory, thereby helping children create links between the new words and those in their existing lexicon. Sheng (2007) has shown that school-age children with better connected semantic networks demonstrate better lexical access, which leads to better word production. This is particularly important for children with SLI, who often demonstrate deficits in semantic organization (Sheng, 2007), difficulty accessing related semantic concepts, and difficulty discriminating among semantic neighbors (McGregor & Waxman, 1998). Third, we hypothesized that phonological encoding cues would make the new words' onsets and rimes more salient and keep them activated in short-term phonological memory, resulting in storage of more accurate and well-specified phonological representations. This is also important for children with SLI, who have difficulty storing accurate phonological representations and difficulty producing new words (Gray, 2005).

To manipulate PP and control for ND we selected nonwords developed by Edwards, Beckham, and Munson (2004) that contained high- or low-sublexical frequency sequences with no phonological neighbors (low ND). Storkel and colleagues (Storkel, 2001, 2003, 2004; Storkel & Maekawa, 2005; Storkel & Rogers, 2000) have demonstrated that children with TD learn high-PP/high-ND nonwords faster than low-PP/low-ND nonwords (including verbs, nouns and homonyms); however, this finding is tempered by results from a more recent adult word learning experiment by Storkel, Armbruster and Hogan (2006) wherein adults learned to produce a *lower* proportion of words with high-probability phonotactic sequences than low-probability phonotactic sequences, in contrast to Storkel et al.'s earlier findings with children. The authors suggested that the low-frequency advantage was due to low-probability nonwords being less wordlike than high-probability words, making them ‘stand apart’ from other words stored in the lexicon. Potentially this difference ‘triggers’ the creation of a new phonological representation on the first exposure. The authors attributed the difference in findings between their child and adult studies to the control of ND in their adult study. Importantly, the PP of nonwords varied orthogonally with ND. The authors suggested that the high-density advantage found for new word production in their adult study was attributable to word learning performance *after* the initial phonological representations of words had been stored. In other words, high PP promotes the initial creation of phonological representations, but high ND promotes word elaboration with more exposures. To date, no study has examined whether a high PP advantage may be found in young children when ND is controlled. Therefore, the second purpose of this study was to determine whether a high- vs. low-frequency sublexical fast mapping or word learning advantage would be found in young children. If Storkel and colleagues' hypothesis concerning low-probability nonwords triggering word learning is upheld, we would expect the low-frequency advantage to be more apparent during fast mapping than in later word learning.

The familiarity children have with the object or action they are learning to name also has the potential to affect word learning performance. If children already have a name for an object, does this facilitate or inhibit word learning? Is there an advantage to having a previously stored semantic representation (and name) for an object so that only the new phonological representation must be stored (e.g. dalmation →dog), or do previously stored phonological, lexical and semantic representations inhibit word learning? When children are asked to name a familiar object, the stored name would presumably become activated and compete for retrieval. This could interfere with retrieval of the new name. In this study, each of the four words children learned in each condition varied according to high- or low-sublexical sequences or familiar vs. unfamiliar objects so that one word was high/familiar, one low/familiar, one high/unfamiliar, and one low/unfamiliar. Therefore, the second purpose of this study was to assess the effect of phonotactic probability and object familiarity on word learning. The specific research questions concerning sublexical frequency and object familiarity were:

5 Which combination of sublexical frequency and object familiarity results in the best fast-mapping comprehension and production for each group?

6 Which combination of sublexical frequency and object familiarity results in the best word learning comprehension and production for each group?

7 Which combination of sublexical frequency and object familiarity results in the best post-task performance as measured by comprehension or production measures for each group?

Method

Overview

Three groups of children participated in this study: children with SLI, an age- and gender-matched group, and a vocabulary- and gender-matched group. Each child learned three sets of four words (counterbalanced across conditions and groups), one set in the no cue, one in the phonological cue, and one in the semantic cue condition. In each condition fast mapping comprehension and production were measured the first day of the study and word learning comprehension and production were measured the next three days using the same set of words. Two words in each set contained high-frequency sublexical sequences and two contained low-frequency sublexical sequences. Two of the objects children learned to name in each set were already familiar to them; thus, they already had a name for the object, and two were unfamiliar. Each aspect of the study is described in more detail below.

Participants

One hundred twenty-five children participated in the study: 42 with SLI, 42 with TD matched individually for age and gender to children with SLI (AM group; ± 3 months), and 41 with TD matched individually for expressive vocabulary and gender to children with TD [VM group; ± 1 SD using raw scores on the Expressive Vocabulary Test (EVT; Williams, 1997)]. Participants were between the ages of 3;1 (years; months) and 5;9 and spoke English as their primary language according to parent report. No child was bilingual. Table 1 provides descriptive information about the three groups. Parents consented to their child's participation in the study per university Internal Review Board requirements for human subjects' protection.

Children with SLI were recruited from local public and private preschools. To be included in the study children with SLI were required to qualify for special education services in their school. In Arizona children qualify as language impaired when they score more than 1.5 *SDs* below the mean on two norm-referenced language tests administered by their school clinician. Children with TD were recruited from public and private preschools and daycare centers. Each child met the following criteria as determined by an ASHA certified speech-language pathologist:

1. Hearing within normal limits bilaterally (25 dB HL) at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz (American National Standards Institution [ANSI], 1989).
2. Normal nonverbal intelligence as indicated by a standard score of 75 or above on the Nonverbal scale of the K-ABC-II (Kaufman & Kaufman, 2004).
3. For children with SLI, no evidence of serious neurological problems or developmental disorder other than language, articulation, or phonological problems, as reported by the parent and teacher.
4. Adequate speech intelligibility for applying the scoring procedures.
5. For AM and VM groups, normal speech, language, motor, and cognitive development as reported by parent and teacher.

In addition a certified speech-language pathologist administered a battery of assessments to describe the speech and language skills of all participants. These included the Peabody Picture Vocabulary Test—3rd Edition (PPVT-III; Dunn & Dunn, 1997), the Expressive Vocabulary Test (EVT; Williams, 1997), the Structured Photographic Expressive Language Test—3rd Edition (SPELT-III; Dawson, Stout, & Eyer, 2003) or the Structured Photographic Expressive Language Test—Preschool (SPELT-P; Werner & Kresheck, 1983), the Antonyms, Sentence Completion and Paragraph Comprehension subtests of the Comprehensive Assessment of Spoken Language (CASL; Carrow-Woolfolk, 1999), the Bankson-Bernthal Test of Phonology (BBTOP; Bankson & Bernthal, 1990), and The Renfrew Bus Story (Cowley & Glasgow, 1994). Scores are reported in Table 1. To calculate scoring reliability 10% of the assessments were scored by a second speech-language pathologist (SLP). Average point-to-point scoring agreement on the standardized assessments was 99.5% (range 98.6-100%).

We also administered a nonword-repetition task (Dollaghan & Campbell, 1998) to assess short term phonological memory. Nonwords were presented to children by computer via headphones with an attached microphone. Children's repetitions were recorded into. WAV computer files. Trained research assistants (RAs) listened to the digital audio files and calculated the percent phonemes correct for each child. Phonemes were scored incorrect if the child substituted or omitted a phoneme; however, distortions and additions were not scored as incorrect. Due to a computer malfunction some children's recordings were truncated so that we could not use their nonword repetition data. As reported in Table 1, the AM group scored significantly higher than the SLI group, but the AM and SLI groups did not differ significantly from the VM group. To calculate scoring reliability 26% of the children's nonword repetition. WAV files were selected for double scoring by a second RA, with approximately one third coming from each participant group. The mean point-to-point agreement for the percent phonemes correct for each word was 94% (range: 78-96%).

Although the AM group scored significantly higher than the SLI group on all norm-referenced speech and language tests and on the nonword repetition task, it is important to note that means for the SLI group on the nonverbal cognitive measure and the vocabulary and expressive phonology measures were within the normal range. However, the SLI mean on the SPELT-III, a test of expressive grammar and morphology, was more than 1 SD below the normative mean, with 81% of the group scoring below 85. In addition, 59% of the SLI group scored lower than 85 on the BBTOP. This suggests that children in the SLI group demonstrated impaired expressive grammar and morphology and a substantial proportion also demonstrated speech sound disorders, which is not unusual for a clinically-referred sample (Zhang & Tomblin, 2000). It is also important to note that on average, mothers of all three groups had completed 15 years of education. There is a positive correlation between increased maternal education and children's language skills (Beitchman, 2008; Magnuson, Sexton, Davis-Kean and Huston, 2009) that could contribute to the relatively high vocabulary scores of children in this study. However, it is not unusual for studies of children with SLI to include children with receptive (e.g. Alt, Plante & Creusere; Mainela-Arnold, Evans & Coady, 2008; Dunn, Flax & Sliwinski, 1996; Gray, 2004; Marchman, Wulfeck & Ellis Weismer, 1999; McGregor, Newman, Reilly & Capone, 2002) or expressive vocabulary scores within the normal range (e.g. Dunn, Flax, Sliwinski & Aram,1996; Gray, 2003; Kiernan & Snow, 1999; Sheng & McGregor, 2010).

Word Learning Materials

Target and common objects—Target objects that children learned to name were selected from a variety of craft and hardware items. The selection process is described in Gray (2005). Objects that were familiar and unfamiliar to both adults and children were included. The twelve target objects were randomly assigned to three sets (A, B, and C) described in Table 2. Additional common objects that children could readily name were also included (e.g., shovel, spaceship) to encourage children's participation in production tasks.

Target words—The twelve two-syllable nonwords used as target names were chosen from a list developed by Edwards, Beckman and Munson (2004) (see Table 2). Six contained a low-frequency sublexical sequence and six contained a high-frequency sublexical sequence. These contrasting sequences were in the same position within similar nonwords, with two sequences in word-initial clusters, one sequence in a word-medial cluster, and three in word-final clusters. None of the words had a phonological neighbor (low ND). Two high- and two low-sequence nonwords were randomly assigned to each word set (A, B or C), with one high and one low naming a familiar object and one high and one low naming an unfamiliar object.

Play sets—The target and common objects were used during play with Playmobile™ toys. Three play sets, including an adventure island (island with a swinging bridge, water, boat and four people), mining, (mine, wagon with horses, beans, and four people) and space set (spaceship, sand, four people) were counterbalanced across children and word sets.

General Procedures

After three assessment sessions children participated in the fast mapping and word learning portions of the study. These tasks were scored live. On the first day children completed the fast mapping task for their first word set. Days 2-4 they completed the word-learning task. On day 5 they completed comprehension and production post-tests. They followed the same schedule with their second and third word sets so that each word set required five school days to complete.

Sessions were scheduled for 15 consecutive school days; however, some interruptions occurred due to illness, holidays, and absences. The mean number of school days required to complete the study was 20.56 (SD = 5.53). Each daily research session lasted approximately 30 minutes. Children accompanied their RA to a separate room at their preschool or home, where they sat at a table or on the floor. RAs were required to demonstrate standardized presentation and scoring of the research tasks prior to study initiation. Fifty-six of the 125 participants had the same RAs for all three conditions. The remaining children had one, two, or three different RAs for the three conditions. The RAs were blind to group and they were assigned primarily by the geographic location where they lived so that it would be convenient to work with the children; therefore, they had different mixes of SLI, AM and VM children and they each worked with 1 to 8 children.

Fast Mapping

The fast mapping task was presented in three blocks to assist RAs in their intervention delivery. During Block I, the RA modeled the name for each of the four target and four common objects as they were presented to the child (e.g., “This is the [target word]”). Next, the RA administered a comprehension probe for each of the target and common objects (e.g., “Hand me the [target word]”). Finally, the RA administered a production probe for each object (e.g., “What's this?” or “What are you holding?”). The procedures for Blocks II and III were identical to Block I. All eight objects (four target, four common) were visible during these probes. The RA provided the models and probes for each word in different orders across blocks. Children received one point for each correct response to a probe, with no feedback regarding the accuracy of their responses. In total the names for each target and common object were modeled three times, accompanied by three comprehension and three production probes. Because the RA said the name of each object for each of the three comprehension probes, the child actually heard each word spoken six times by the RA during the fast mapping task.

Word Learning

The same eight objects used in the fast-mapping task, along with Playmobile™ toy sets that were not used during fast mapping, were present during word learning. Word learning was organized into four blocks that are illustrated in Appendix C. They are similar to procedures utilized in Gray (2005). Within each word learning block models of the target word were provided before proceeding to a comprehension trial for that word, with the comprehension trial administered before the production trial. The models and trials for all words were completed within one block before moving to the next.

During Block I the RA modeled the name of each target object as it was presented to the child, followed by a prompt for immediate imitation of the name (e.g., “This is the [target] … say [target]”), followed by a semantic or phonological cue (e.g., “It's made of plastic” for the semantic cue or “It starts with /t/” for the phonological cue). In the no cue condition the RA gave the model, imitation prompt and feedback, but no additional information. A second model, imitation prompt, and cue (or no cue) for each object followed. Next, the RA administered a comprehension trial for each object (e.g., “Please hand me the [target]”) followed by immediate feedback regarding the accuracy of response (e.g., “Yes, that's the [target]” or, for an incorrect response, “Here's the [target]”). Finally, the RA administered a production trial for each object (e.g., “What are you holding?”) followed by immediate feedback regarding the accuracy of response (e.g., “Right, that's the [target]” or, for an incorrect response, “Here's the [target]”). All objects and toys from the play sets were available as choices during the comprehension and production trials. After completing Block I the RA followed the same procedures for Blocks II and III. Block IV differed from Blocks I, II, and III in that no cues were presented. Only one model accompanied by an imitation prompt, one comprehension trial and one production trial, both with feedback, were administered. To summarize, in each word learning session the child completed four comprehension and four production trials. Because the imitation requests, comprehension trials, and feedback required the RA to say the name of each object, the child actually heard each name spoken thirty-three times each session.

Responses to comprehension trials were scored correct if the child showed the RA the correct target object. Responses to production trials were scored correct if the child produced all of the target word's phonemes correctly, or consistently produced the same phonological variation of the word that the child used in immediate imitation of target words.

To reach criterion for comprehension or production of a word children were required to respond correctly to 3 of 4 trials on 2 of 3 consecutive study days. Trials to criterion were calculated by counting the number of trials elapsed before a child reached learning criterion for either comprehension or production of each word. Fast mapping probes *were not* counted as trials. Teaching continued after a child met learning criterion for a particular word to permit performance comparisons at the end of the study when all children had experienced an equal number of word exposures.

Procedural fidelity and scoring reliability were assessed by having 16% of the experimental sessions scored by a second RA live or by watching the session on videotape. The average point-to-point agreement for procedural fidelity was 99.6% (range 96-100%) and for scoring reliability was 98.6% (range 72-100%).

Semantic and Phonological Conditions

Children had the opportunity to learn one set of words in each of three conditions, semantic, phonological, and no cue. The order of conditions was counterbalanced across children in each group. In the semantic condition each elicited imitation (described above) was followed by a semantic cue with information about the object's superordinate category, a physical characteristic, an action or use, a part, or an association. For example, cues for the taydowm were, “It's a kind of fruit” (superordinate), “It's orange” (physical characteristic), “You can eat it” (action), “It comes from a tree” (association), “It has a stem” (parts), and “It's kind of like a ball” (physical characteristic).

In the phonological condition each elicited imitation was followed by a phonological cue with the word's initial sound, initial syllable, the word produced by syllable, or a rhyming cue. For example, cues for the taydowm were, “/t/ /t /t/,” (initial sound), “It starts with /t/” (initial sound), “It starts with tay” (initial syllable), “tay and dowm (produced by syllable), “tay (clap) dowm (clap),” “It rhymes with shaydowm” (rhyming).

Post-Task Assessments

Comprehension and production post-task assessments for each word set were conducted after the final day of word learning. The *production* probe asked children to name the object when presented with its picture. The *comprehension* probe asked children to point to a picture of the object out of a field of four when given the name. Color photographs (one target and three foils) appeared in a 2×2 array on each page. The position of the target varied in relation to the foils. One of the foils on each page depicted a play object that was present each day during the word-learning task (e.g., tree), one depicted another target object, and one depicted an object the child hadn't seen during the study that was similar in shape and category to the target object. The probability of a child responding correctly by chance on the comprehension measures (1/4) was higher than for the production probes; however, performance was significantly above chance (one sample t test compared to 25% $t(124) = 43.65$, $p < .0001$).

Procedural fidelity and scoring reliability were assessed by having 15.2% of the experimental sessions scored by a second RA live or by watching the session on videotape. The average point-to-point agreement for procedural fidelity was 99% (range 99-100%) and for scoring reliability was 98.3% (range 83-100%).

Results

Results for encoding cues were analyzed using separate repeated-measures, mixed factorial ANOVAs with group (SLI, AM, VM) as the between-group factor and condition (no cue, phonological, semantic) as the within-group factor. Results for word and object type were also analyzed using separate repeated-measures mixed factorial ANOVAs, except that the within-group factor was word/object type (high/familiar, low/familiar, high/unfamiliar, low/unfamiliar). The Greenhouse-Geisser Test was used for all within-group comparisons. Planned post-hoc comparisons for significant main effects employed a Bonferroni correction for multiple comparisons.

Effect of Encoding Cues

Fast mapping—Children had the opportunity to fast map 12 words, four in each of the three conditions. Comprehension and production were assessed for each word using three comprehension and three production probes per word. The estimated marginal means and standard errors for the number of correct responses to fast mapping comprehension and production probes for each group by condition are reported in Table 3.

There was no effect of condition for comprehension $F(1.96, 238.7) = .11$, $p = .84$ or production $F(1.99, 243.4) = 1.19$, $p = .30$ and there were no between-group differences for comprehension $F(2, 122) = 2.77$, $p = .07$ or production $F(2, 122) = 1.37$, $p = .26$. In general, the fast mapping task was difficult for all children. The AM group had more correct responses for comprehension than the other groups, but still averaged only 4 out of 12 possible points in each condition. Production was especially difficult with all groups averaging less than 1 out of 12 correct. The low number of correct responses, especially for production, could limit the ability to detect group differences.

Number of words learned to criterion—The same 12 words taught during fast mapping were carried forward in the same conditions to the word learning portion of the study. Four comprehension and four production probes were administered for each word in each of the three word learning days for a total of 12 comprehension and 12 production probes per word. Recall that to reach criterion for comprehension or production of a word, children were required to respond correctly to three of four probes on two consecutive days. The estimated marginal means and standard errors for the number of words learned by each group in each condition are reported in Table 3. Although all groups learned to comprehend more than half of the words in each condition, word learning was low for production averaging between one and two words.

There was no effect of condition for the number of words children learned to comprehend $F(1.99, 243.2) = 1.39$, $p = .25$ and no between-group differences $F(2, 122) = 2.11$, $p = .13$. There was a significant effect for condition for the number of words children learned to produce $F(1.98, 241.36) = 4.06$, $p = .02$, $\eta_p^2 = .03$, but no significant between-group differences $F(2, 122) = .63$, $p = .53$. Planned post hoc comparisons showed that significantly more words were learned in the no cue condition than the semantic condition, with the phonological condition differing from neither.

Trials to criterion—The estimated marginal means for the number of trials children required to reach learning criterion for comprehension and production of each word is reported in Table 3. These data include trials for words in which children reached learning criterion; therefore, the number of children included in the analyses are limited to those who learned at least one word in each condition and the power to detect differences is reduced. Condition was not significant for comprehension $F(1.93, 160.1) = .67$, $p = .51$ or production

F(1.74, 47.08) = .31, $p = .70$ and there were no between-group differences for comprehension *F*(2, 83) = .39, $p = .68$ or production. *F*(1, 27) = .75, $p = .48$.

Post-task assessment of comprehension and production—Children completed comprehension and production post-tasks at the end of the word learning task in each condition. Each correct response earned one point so that four points were possible for comprehension and four for production in each condition. For comprehension all groups averaged more than 3 correct across conditions. The estimated marginal means and standard errors for comprehension and production are reported in Table 3. There was no effect of condition *F*(1.974, 240.877) = 2.84, $p = .06$ and no between-group differences *F*(2, 122) = 1.88, $p = .16$. There was a significant condition×group interaction *F*(3.949, 240.877) = 2.61, $p = .04$, $\eta_p^2 = .04$. Post hoc tests revealed that scores in the no cue condition were significantly higher than either the phonological or semantic conditions, which did not differ. This was due primarily to the SLI group's higher score in the no cue than phonological and semantic conditions. For production there was no effect of condition *F*(1.967, 239.941) = .98, $p = .38$ and no between-group differences *F*(2, 122) = .22, $p = .80$.

Effect of Word/Object Type

Fast mapping—Within each of the three conditions, one word contained a low-frequency sublexical sequence naming an unfamiliar object (low/unfamiliar), one a high-frequency sublexical sequence naming an unfamiliar object (high/unfamiliar), one low-frequency sequence naming a familiar object (low/familiar), and one high-frequency sequence naming a familiar object (high/familiar). Comprehension and production were assessed for each word using three comprehension and three production probes per word. The analyses were collapsed across condition because each condition had the same word/object types and because condition was generally not significant in earlier analyses. The estimated marginal means and standard errors for the number of correct responses for fast mapping comprehension and production probes are reported in Table 4. There was no effect of word/object type for comprehension *F*(2.61, 318.8) = 1.51, $p = .22$ or production *F*(2.73, 333.4) = .73, $p = .52$ and there were no between-group differences for comprehension *F*(2, 122) = 2.71, $p = .07$ or production *F*(2, 122) = 1.37, $p = .26$.

Word learning comprehension and production

To assess whether word learning differed by word/object type for each group the number of correct responses to comprehension and production probes was analyzed for the last day of word learning when children had received the maximum number of exposures to each word/object type. The analyses were collapsed across condition. The estimated marginal means and standard errors for the number of correct responses to comprehension and production probes are reported in Table 4.

For comprehension there was a significant effect of word/object type *F*(2.965, 361.709) = 9.15, $p < .001$, $\eta_p^2 = .07$, but no between-group differences *F*(2, 122) = 1.73, $p = .18$. Planned post-hoc comparisons showed that words with low probability sequences naming unfamiliar objects (low/unfamiliar) had more correct responses than any other type. In addition, words with high probability sequences naming unfamiliar objects (high/unfamiliar) had more correct responses than words with high probability sequences naming familiar objects (high/familiar).

Similar to comprehension, there was a significant effect of word/object type for word production *F*(2.792, 340.575) = 17.72, $p < .001$, $\eta_p^2 = .13$, but no between-group differences *F*(2, 122) = .25, $p = .78$. Post-hoc comparisons showed significant differences between all word/object types with the most correct responses for low/unfamiliar followed by low/familiar, high/unfamiliar and high/familiar.

Post-task assessment of comprehension and production—The estimated marginal means and standard errors for the number of correct responses on post-task comprehension and production probes are reported in Table 4. For comprehension there was a significant effect of word/object type $F(1.963, 239.432) = 6.47$, $p < .001$, $\eta_p^2 = .05$, but no between-group differences $F(2, 122) = 1.98$, $p = .14$. Post-hoc comparisons showed that the number correct for low/unfamiliar, low/familiar and high/unfamiliar word/object types did not differ significantly, but all were higher than the high/familiar type.

There was also a significant effect of word/object type for word production, $F(2.958, 360.863) = 9.33$, $p < .0001$, $\eta_p^2 = .07$, but no between-group differences $F(2, 122) = .222$, $p = .80$. Post-hoc comparisons showed that words with low probability sequences naming unfamiliar objects (low/unfamiliar) had more correct responses than any other type.

Discussion

The first purpose of this study was to determine whether phonological or semantic encoding cues improved fast mapping or word learning efficiency in young children when words were taught in an SLC. In addition to providing a high degree of experimental control, the SLC provided multiple models of words across several days and multiple opportunities for children to practice saying the words. These procedures were designed to improve the word learning performance of children with SLI so that they could learn a sufficient number of words to allow the effects of encoding cues, phonotactic probability and object familiarity to be studied.

We hypothesized that focusing attention on the phonological or semantic characteristics of words could reduce the need for children to deduce these important characteristics on their own, that encoding cues would activate related concepts in semantic memory helping children create links between the new words and those in their existing lexicon, and that phonological encoding cues would make the new words' onsets and rimes more salient keeping them activated in short-term phonological memory. Results indicated that encoding cues had no effect on fast mapping performance for any group, nor on the number of words children learned to comprehend. In fact, encoding cues actually appeared to be detrimental to word production for children with TD. Overall, children learned to produce significantly more words to criterion in the no cue and phonological conditions than the semantic condition. Post hoc analyses showed that the significant condition effect was due to a clear no cue advantage for the AM group over both the phonological and semantic conditions and a clear no cue and phonological condition advantage over the semantic condition in the VM group. The SLI group showed no differences for word learning production. However, the SLI group showed a no cue advantage over both phonological and semantic encoding conditions in the post-task assessment of comprehension, implying that encoding cues could be detrimental to their word learning as well.

These results suggest that phonological or semantic information, provided immediately after a word is modeled, may interfere with the elaboration of new words. Two possible reasons include the additional cognitive processing demands associated with the encoding cues or interference that occurred as a result of the cues. It is possible that the encoding cues shifted children's attention from processing the phonological or semantic characteristics of the words to processing the cues, thereby hindering word learning. It is also possible that the encoding cues primed words in the child's existing lexicon and, rather than strengthening the representation as hypothesized, actually interfered with storage of the new word's phonological representation. Because the no cue advantage was present for production only, it suggests that the strength of the phonological representation was compromised because production requires a more specified phonological representation than comprehension.

Although the SLC was the same in Gray (2005) and the present study, there were also important differences. The 2005 study provided 4 vs. 3 days of word learning, used different words and objects, and children learned 2 rather than 3 word lists. These changes were a response to recent research findings regarding factors that influence word learning, including phonotactic probability and neighborhood density, and were necessary for answering the current research questions, but the task differences make it difficult to compare results across studies. Nevertheless, it is interesting to ask whether the SLI and AM groups in the two studies differed in ways that might affect responses to the semantic or phonological encoding cues. To determine whether the SLI and AM groups differed in the two studies we calculated Cohen's *d* effect sizes for measures of interest. The CASL Antonyms subtest assessed children's semantic knowledge. Between-group effect sizes for the SLI and AM groups were d =2.5 in the 2005 study and d=.78 in the current study, suggesting that the current SLI group had better semantic knowledge relative to the AM group. This coincided with semantic cues promoting better comprehension of new words than phonological cues in the 2005 SLI group. It is possible that in the earlier study the SLI group benefitted from semantic cues because they had less well developed semantic knowledge, but that the SLI group in the current study, by virtue of their better semantic knowledge, did not benefit from the semantic cues.

We hypothesized that encoding cues would help children keep words active in short-term phonological memory; therefore, it is also interesting to ask whether the current SLI group had poorer short-term phonological memory, as measured by nonword repetition (Dollaghan & Campbell, 1998), than the 2005 SLI group. If so, this could reduce the benefit of encoding cues because they may have taxed short-term phonological memory. In 2005 the SLI group mean for percent phonemes correct on the nonword repetition task was 62.45 (SD=14.07) and in the current study it was 57.98 (SD=16.10). The relatively small between-group effect size of d=.28 between the earlier and present studies does not suggest that phonological memory differences played an appreciable role in the current study results.

It is unusual for an SLI group to perform as well as an AM group in a word learning study. Is it possible that the SLI group in the present study had particularly mild language impairment or that the AM group had low language ability? As discussed in the Method section, each group had receptive and expressive vocabulary standard scores within the normal range; however, the SLI group's PPVT-III standard scores were nearly one standard deviation below the AM group. Further, SLI group SPELT-III standard scores were two SDs below the AM group. These between-group differences are similar to previous studies where the SLI group learned to comprehend and produce significantly fewer words, and at a slower rate, than an AM group (Gray, 2004, 2005). In fact, compared to Gray's 2005 study, the between group effect sizes for scores on the K-ABC II, PPVT-III and BBTOP were larger in the current study. This suggests that factors other than participant characteristics contributed to the lack of between-group differences in the current study, but clearly our results may not generalize to SLI groups that demonstrate a different profile of speech and language strengths and weaknesses. We hypothesize that the supported learning context, in conjunction with the particular word and object characteristics used in this experiment, provided the necessary support for children with SLI to learn as many words, with the same efficiency, as their peers. It is important to note that children would not receive this many closely spaced models of new words paired with immediate feedback in natural contexts, and also that children learned to produce relatively few words to criterion (1-2) in this study.

Results showed a clear low/unfamiliar word learning advantage for both comprehension and production, with the effect more pronounced for production. By the last day of word learning, words with low PP sequences were produced more often than words with high PP sequences, regardless of whether they named familiar or unfamiliar objects. When comparing words with high PP sequences, there were more correct responses for unfamiliar than familiar objects. At post-task assessment, high/familiar words showed a distinct comprehension *disadvantage*. For production, the low/unfamiliar advantage continued and remained more pronounced for production. Taken together, results showed a clear learning advantage for words with low PP sequences and, to some extent, for unfamiliar objects; however; these advantages were not apparent during the fast mapping portion of the study.

These results add to Storkel, Armbruster and Hogan's (2006) findings that low PP facilitates word learning in adults, showing that words with low probability sublexical sequences also promote word learning in young children. Storkel and colleagues hypothesized that low probability words "…stand apart from other sounds sequences as unique" (p. 1188), thereby causing the listener to attend to them immediately and 'triggering' word learning upon the first exposure. In this study, low probability sequences did not appear to trigger word learning faster than high probability sequences during the fast mapping portion of the study when children had received a similar number of exposures to words as in the adult word learning study (six vs. seven). However, the proportion of correct production responses was much higher in the adult study (>40% adult vs. <25% children) and the adult results were based on an analysis of partially correct plus fully correct responses. That is, adults received credit for a partially correct name if they produced two of three phonemes in the name and full credit if they produced three of three phonemes. Both types of responses were added together for the PP analysis. In the current study children did not receive credit for partial responses; therefore, the kind of early low probability effect found by Storkel and colleagues may not have been detected during fast mapping. Nevertheless, our results suggest that the low probability advantage was present after children had many exposures to words and was observable over and above the effect of object familiarity. Because all words in the current study were from low density neighborhoods, it is not known whether the same results would be obtained with words from higher density neighborhoods.

There are several other differences between the Storkel, Armbruster and Hogan (2006) study and the present study with the potential to influence findings. First, our nonwords were longer, containing 5 vs. 3 phonemes. With other factors being equal, longer words would presumably be more difficult to learn and therefore more exposures would be required before PP effects could be observed. Second, the PP probability of words in the Storkel et al. study was based on the entire word rather than a single high- or low-frequency sublexical sequence embedded within the word. This means that the difference between high and low PP words in the Storkel et al. study was likely more pronounced than the current study, which could explain why PP effects were not seen during fast mapping. The contrast between the high- and low-frequency sublexical sequences would not stand apart from other sounds sequences as readily in the current study. Third, Storkel et al. presented the words via tape recording vs. live voice, which ensured that each presentation was controlled for duration. It is possible that RAs in this study articulated words with low-frequency sublexical sequences with longer durations than those with high-frequency sublexical sequences. Munson (2001) reported that adults use longer durations to articulate words with low-frequency phoneme sequences than high-frequency sequences. Speakers may do this because they realize that words with low PP are inherently more difficult to perceive, so they modify their production to make words more perceptible (Munson & Soloman, 2004; Stephenson, 2004). If this was the case in this study, the low PP advantage could be due to longer articulation durations rather than to PP, or to a combination of both factors. We were not able to test this hypothesis in the current study, but clearly this is an important question for future word learning research.

All groups appeared to have more difficulty learning a second name for a familiar object than learning an initial name for an unfamiliar object. This effect was more subtle than the low PP advantage, but given words varying in PP that name known or unknown objects, results showed a learning continuum with low/unfamiliar words easier to learn than high/familiar words. The unfamiliar vs. familiar advantage could be due to interference. When asked to name an object, stored words with similar acoustic-phonetic patterns are activated in memory, as are words for related semantic concepts. Activated words compete for retrieval with the target word. Priming experiments have shown this effect in children with TD as young as four (Brooks & MacWhinney, 2000; Gray, Reiser & Brinkley, submitted; Jerger, Martin & Damian, 2002; Plaut & Booth, 2000) and in children with SLI as young as seven (Seiger-Gardner & Brooks, 2008). When children were asked to provide the new name for an object the existing name, with its presumably stronger phonological and semantic representations, competed for retrieval. The combination of a poorer phonological representation of the new word because of its high PP, paired with the competing stronger existing word, made it less likely that the child would produce the new name correctly.

Conclusions

Because of the negative effect that poor vocabulary development has on oral and written language achievement it is important to develop treatments that speed the word learning process for children with SLI. This study investigated whether phonological or semantic encoding cues improved word learning efficiency in young children with TD or SLI. Results suggest that rather than helping, the encoding cues had a detrimental effect on word learning.

New findings demonstrated that preschoolers with TD and SLI learned words with low probability sequences more readily than words with high probability sequences and children appeared to have more difficulty learning a second name for a familiar object than learning an initial name for an unfamiliar object. Results suggest that phonotactic probability and previous lexical knowledge affect word learning in similar ways for children with TD and SLI and that encoding cues were not beneficial for any group.

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Table 1

Participant Description Information Including Mean (SD) Age, Mother's Years Of Education, Standard or Raw Scores on Assessments

Measure	SLI group *n* = 42 M	SLI group *n* = 42 SD	AM group *n* = 42 M	AM group *n* = 42 SD	VM group *n* = 41 M	VM group *n* = 41 SD
Age in Months	56.67^{**}	6.07	$54.76^{\dagger\dagger}$	5.24	$45.24^{**\dagger\dagger}$	5.00
Mother's Yrs of Ed	15.26	1.77	15.43	1.53	15.93	1.74
K-ABC II SS	$101.88^{**\dagger\dagger}$	13.20	109.50^{**}	10.29	$109.34^{\dagger\dagger}$	13.99
PPVT-III SS	$96.31^{**\dagger\dagger}$	8.84	110.57^{**}	13.25	$105.49^{\dagger\dagger}$	12.01
EVT SS	$98.79^{**\dagger\dagger}$	9.58	107.76^{**}	9.70	$112.39^{\dagger\dagger}$	9.52
EVT RS	45.57^{**}	6.30	$50.43^{**\dagger\dagger}$	5.83	$45.51^{\dagger\dagger}$	6.21
BBTOP-WI RS	$47.83^{**\dagger\dagger}$	21.24	69.24^{**}	10.15	$65.13^{\dagger\dagger}$	12.64
BBTOP-WI SS	$82.29^{**\dagger\dagger}$	14.41	101.62^{**}	10.89	$103.46^{\dagger\dagger}$	12.48
CASL-SC SS	$91.48^{**\dagger\dagger}$	9.23	105.95^{**}	13.39	$108.78^{\dagger\dagger}$	13.02
CASL-PC SS	$87.48^{**\dagger\dagger}$	17.41	106.64^{**}	20.50	$101.41^{\dagger\dagger}$	18.65
CASL-A RS[c]	9.50^{**}	3.46	$12.21^{**\dagger\dagger}$	3.28	$9.68^{\dagger\dagger}$	3.47
SPELT-III SS[a]	$74.83^{**\dagger\dagger}$	8.08	104.89^{**}	9.98	$110.83^{\dagger\dagger}$	7.06
SPELT-P RS[b]					18.76	3.98
Bus Story-I RS	12.80^{**}	5.54	$19.12^{**\dagger\dagger}$	7.63	$13.41^{\dagger\dagger}$	5.89
Bus Story-L RS	6.09^{**}	1.64	$8.03^{**\dagger\dagger}$	1.56	$6.65^{\dagger\dagger}$	1.56
NWR-PPC[c]	57.98^{*}	16.10	70.24^{*}	17.97	64.65	21.20

Note. SLI = specific language impairment; AM = age-matched group; VM = vocabulary-matched group. K-ABC II SS = Nonverbal scale of the Kaufman Assessment Battery for Children - Second Edition Standard Score (Kaufman & Kaufman, 2004); PPVT-III SS = Peabody Picture Vocabulary Test—3rd Edition Standard Score (Dunn & Dunn, 1997); EVT SS = Expressive Vocabulary Test Standard Score (Williams, 1997); EVT-RS = Expressive Vocabulary Test Raw Score; BBTOP WI = Bankson-Bernthal Test of Phonology Word Inventory Standard Score (Bankson & Bernthal, 1990); CASL-SC SS = Comprehensive Assessment of Spoken Language Sentence Completion Subtest Standard Score (Carrow-Woolfolk, 1999); CASL-PC = Comprehensive Assessment of Spoken Language Paragraph Comprehension Subtest Standard Score; CASL-A RS = Comprehensive Assessment of Spoken Language Antonyms Subtest Raw Score. SPELT-III SS = Structured Photographic Expressive Language Test—3rd Edition Standard Score (Dawson, Stout, & Eyer, 2003); SPELT-P RS = Structured Photographic Expressive Language Test-Preschool Raw Score (Werner & Kresheck, 1983). Bus Story- I RS = Renfrew Bus Story Information Units Raw Score (Cowley & Glasgow, 1994); Bus Story - L RS = Renfrew Bus Story Sentence Length Raw Score; NWR-PPC = Nonword Repetition Percent Phonemes Correct (Dollaghan & Campbell, 1997).

[a]SPELT-III administered only to 4- and 5-year olds (*n* = 92).

[b]SPELT-P administered only to 3-year olds (*n* = 33).

[c]Due to technical problems scores for the NWR task are not available for all participants, SLI $n = 30$, AM $n = 32$, VM $n = 37$.

[*] $p < .05$.

[**] $p < .01$.

[††] $p < .01$.

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Table 2

Description of Target Words and Objects

ObjectType	Sublexical Frequency	Set A	Set B	Set C
Unfamiliar	Low	/vugim/ (copper tube)	/moiped/ (plastic plug)	/jugoin/ (hose clamp)
	High	/maebep/ (plastic wheel)	/vIdaeg/ (silver connector)	/bogib/ (wooden block with slots)
Familiar	Low	/tedaum/ (kind of orange)	/donug/ (kind of pepper)	/motauk/ (kind of pine tree)
	High	/bedaeg/ (kind of flower)	/petik/ (kind of cactus)	/podaud/ (kind of nut)

Table 3

Estimated Marginal Means (SEs) for the Number of Correct Responses on Fast Mapping, Number of Words Learned to Criterion, Number of Trials to Criterion for the Number of Words Learned, and the Number of Correct Responses on Post-Tasks by Condition

Group	SLI	AM	VM
Number of Correct Responses for Fast Mapping			
Comprehension	*n* = 42	*n* = 42	*n* = 41
No Cue	3.67 (.363)	4.67 (.363)	3.37 (.367)
Phonological	3.64 (.393)	4.17 (.393)	3.71 (.398)
Semantic	3.79 (.336)	4.24 (.336)	3.34 (.340)
Production	*n* = 42	*n* = 42	*n* = 41
No Cue	.238 (.127)	.310 (.127)	.439 (.129)
Phonological	.119 (.109)	.381 (.109)	.463 (.110)
Semantic	.214 (.101)	.286 (.101)	.122 (.102)
Number of Words Learned to Criterion			
Comprehension	*n* = 42	*n* = 42	*n* = 41
No Cue	3.143 (.184)	2.952 (.184)	2.561 (.186)
Phonological	2.714 (.224)	2.833 (.224)	2.463 (.226)
Semantic	2.833 (.207)	3.024 (.207)	2.512 (.209)
Production	*n* = 42	*n* = 42	*n* = 41
No Cue[a]	1.381 (.192)	1.548 (.192)	1.220 (.195)
Phonological	1.286 (.184)	1.048 (.184)	1.220 (.186)
Semantic[a]	1.405 (.181)	1.048 (.181)	.878 (.183)
Number of Trials to Criterion			
Comprehension	*n* = 29	*n* = 32	*n* = 25
No Cue	9.506 (.257)	9.312 (.245)	9.147 (.277)
Phonological	9.368 (.216)	9.031 (.206)	9.120 (.233)
Semantic	9.333 (.256)	9.365 (.244)	9.493 (.276)
Production	*n* = 14	*n* = 10	*n* = 6
No Cue	10.71 (.439)	9.733 (.519)	9.333 (.670)
Phonological	10.119 (.458)	10.867 (.542)	9.555 (.700)
Semantic	10.357 (.501)	10.133 (.593)	10.333 (.765)
Number of Correct Responses on Post Tasks			
Comprehension	*n* = 42	*n* = 42	*n* = 41
No Cue	3.857 (.126)	3.524 (.126)	3.439 (.128)
Phonological	3.381 (.138)	3.595 (.138)	3.390 (.140)
Semantic	3.452 (.141)	3.619 (.141)	3.146 (.142)
Production	*n* = 42	*n* = 42	*n* = 41
No Cue	2.000 (.201)	1.786 (.201)	1.463 (.204)
Phonological	1.690 (.191)	1.714 (.191)	1.634 (.193)
Semantic	1.762 (.217)	1.857 (.217)	1.902 (.219)

Note. SLI = specific language impairment; AM = age-matched group; VM = vocabulary-matched group.

[a]Conditions are significantly different. Fewer children are included in the production than comprehension results for trials to criterion because children were required to reach learning criterion for at least one word to be included in these analyses.

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Table 4

Estimated Marginal Means (SEs) for Number of Correct Responses for Fast Mapping, Number of Correct Responses to Comprehension and Production Probes on the Last Day of Word Learning, and Number of Correct Responses to Comprehension and Production Probes on the Post-Task by Word/Object Type

Group	SLI *n* = 42	AM *n* = 42	VM *n* = 41
Number of Correct Responses for Fast Mapping			
Comprehension			
Low/Unfamiliar	.857 (.088)	1.032 (.088)	.813 (.089)
High/Unfamiliar	1.008 (0.96)	1.087 (.096)	.846 (.097)
Low/Familiar	.913 (.091)	1.079 (.091)	.911 (.093)
High/Familiar	.778 (.097)	1.032 (.097)	.805 (.098)
Production			
Low/Unfamiliar	.032 (.030)	.095 (.030)	.081 (.030)
High/Unfamiliar	.048 (.036)	.071 (.036)	.106 (.036)
Low/Familiar	.071 (.033)	.095 (.033)	.098 (.033)
High/Familiar	.040 (.022)	.063 (.022)	.057 (.022)
Number of Correct Responses for Last Day of Word Learning			
Comprehension			
Low/Unfamiliar[a]	3.317 (.109)	3.341 (.109)	3.154 (.110)
High/Unfamiliar[b] *	3.214 (.119)	3.190 (.119)	2.943 (.121)
Low/Familiar[b]	2.984 (.118)	3.175 (.118)	2.951 (.120)
High/Familiar[b] *	3.071 (.115)	3.119 (.115)	2.780 (.117)
Production			
Low/Unfamiliar[a]	2.040 (.170)	2.087 (.169)	1.935 (.172)
High/Unfamiliar[b]	1.587 (.169)	1.373 (.169)	1.325 (.171)
Low/Familiar[c]	1.635 (.169)	1.595 (.169)	1.837 (.171)
High/Familiar[d]	1.563 (.168)	1.500 (.168)	1.179 (.170)
Number of Correct Responses on Post Tasks			
Comprehension			
Low/Unfamiliar[a]	2.857 (0.086)	2.738 (0.086)	2.512 (0.087)
High/Unfamiliar[a]	2.667 (0.102)	2.690 (0.102)	2.659 (0.103)
Low/Familiar[a]	2.857 (0.086)	2.738 (0.086)	2.512 (0.087)
High/Familiar[b]	2.500 (0.112)	2.571 (0.112)	2.390 (0.114)
Production			
Low/Unfamiliar[a]	1.714 (0.152)	1.667 (0.152)	1.415 (0.153)
High/Unfamiliar[b]	1.238 (0.161)	1.190 (0.161)	1.220 (0.163)
Low/Familiar[b]	1.310 (0.166)	1.286 (0.166)	1.317 (0.168)
High/Familiar[b]	1.190 (0.155)	1.214 (0.155)	1.049 (0.157)

Note. SLI = specific language impairment; AM = age-matched group; VM = vocabulary-matched group. Within each category of comprehension or production word/object types with different alphabetic superscripts differ significantly (p<.05).