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Lexical–Semantic Organization in Children With Specific Language Impairment

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Abstract

Purpose—To determine whether children with specific language impairment (SLI) show deficits in lexical–semantic organization and, if so, whether these deficits are commensurate with their delay in vocabulary size and whether the deficits affect all children with SLI.

Method—Fourteen children with SLI, 14 age matches (AM), and 14 expressive vocabulary matches (VM) generated 3 associations to each of 48 words. Associations were coded as semantic (e.g., *dog–pet*), clang (e.g., *cow–how*), or erroneous (e.g., *spoon–Disney*).

Results—Relative to the AM children, children with SLI produced fewer semantic responses, more clangs, and more errors. Relative to the VM children, fewer semantic responses and more errors in the children with SLI were found in by-item analyses. Across elicitation trials, semantic responses decreased in the AM and VM children but remained stable in the SLI children. Examination of individual performance in the SLI group revealed that poor semantic performance was associated with a deficit in expressive vocabulary and a gap between receptive and expressive vocabularies.

Conclusions—Significant variability in lexical–semantic organization skills exists among children with SLI. Deficits in lexical–semantic organization were demonstrated by a subgroup of children with SLI who likely had concomitant word-finding difficulties.

Keywords

lexical–semantic organization; specific language impairment; repeated word association; word-finding difficulties

Children with specific language impairment (SLI) have documented deficits in the semantic domain (Brackenberry & Pye, 2005; Kail & Leonard, 1986). For example, the first sign of SLI is often the late onset of vocabulary acquisition (Bishop, 1997). Also, evidence abounds that children with SLI test lower than age-matched peers on static measures of receptive and expressive vocabulary, indicating a deficit in the breadth of their lexicons (e.g., Gray, Plante, Vance, & Henrichsen, 1999; McGregor, 1997). In the present study we test the hypothesis that children with SLI have deficits in lexical–semantic organization. Lexical–semantic organization is instantiated as the number and accessibility of links from a target word to other word entries in a semantic network. We used a repeated word association task to derive an estimate of lexical–semantic organization and compared performance between children with SLI and typically developing peers. We also examined within-group variability to investigate the extent to which a deficit in lexical–semantic organization is characteristic of the SLI population.

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Defining Lexical–Semantic Organization

A network metaphor is used to describe lexical–semantic organization. Integral to this network model of semantic activation are the concepts of nodes, links, and spreading activation (Collins & Loftus, 1975). In this model, words are represented by conceptual nodes. Each node is connected via links to other nodes that share semantic relations. When a node is processed or stimulated, activation spreads out along the network path to other nodes. In a rich semantic network, there are many links connecting the nodes such that the activation of one node primes (or coactivates) many related nodes. For example, the word *finger* may readily activate words such as *toe*, *thumb*, *arm*, *leg*, and *shoulder*, all of which belong to the same semantic category as *finger*. It may also evoke thoughts of another cluster of words such as *fingernail*, *five*, *tap*, *ring*, *glove*, all of which share thematic relations with finger.

An important assumption of the semantic network model is that as activation travels outward from the node of origin, it becomes attenuated (Collins & Loftus, 1975). The decrease in activation is inversely related to the accessibility or the strength of the link in the path. In other words, the node that bears the strongest link to the node of origin is the first to be accessed. The accessibility of a link depends on how often a person uses or encounters that specific pairing of nodes. For example, *finger* and *toe* may be more strongly linked than *finger* and *glove*. Frequent exposures to the *finger* and *toe* duo and the high degree of overlap in meaning may solidify the link between the two. Building an efficient semantic network involves the formation of many links among word nodes and the forging of strong links between certain nodes.

Guided by this semantic network model, we gathered data pertinent to two aspects of lexical–semantic organization in children with SLI: the number of links between semantically related nodes and the accessibility of these links. We note that in more current network models (e.g., McClelland, 1995), a one-to-one correspondence between words/concepts and nodes is no longer posited. Rather, knowledge is distributed across connections between subsymbolic nodes. The present study is compatible with either theoretical instantiation as both models incorporate the notion of activation spreading across a network that is organized semantically.

The Repeated Word Association Task

The word association task is used widely to measure semantic knowledge (De Deyne & Storms, 2008). This task has been used in various formats (De Groot, 1989). In a *discrete word association task*, the participant produces a single response to a word prompt. In a *free word association task*, the participant produces as many responses as possible to a prompt within a set time limit. In a *repeated word association task* (Sheng, McGregor, & Marian, 2006), the prompt is repeated multiple times, and each time the participant gives a single response.

According to the spreading activation model of semantic networks (Collins & Loftus, 1975), upon hearing a prompt (e.g., *finger*) in a word association task, the conceptual node representing that word is activated. Then the activation spreads from one node to others. Nodes bearing strong links to the activated node (e.g., *toe* or *hand*) are immediately activated and are produced early on in free or repeated word association. Weakly linked nodes (e.g., *glove*) receive a smaller and/or delayed activation and are produced later in free or repeated word association. Further, a word like *bookshelf* is probably not accessible at all by the activation and never occurs as a response to *finger*. Through repeated probing, the word association task can yield information about the number and strength of links between semantically related words in a speaker's lexicon.

Developmental studies reveal increases in semantic responses (e.g., *horse–cow*, *saddle*; *give–take*, *gift*) in word association tasks during childhood, suggesting that children are building links between word nodes in their semantic networks (e.g., Cronin, 2002; Entwisle, 1966). In addition to semantic responses, young children often generate *clangs* that bear a pure phonological relationship to the targets. These responses alliterate (e.g., *candy–can*) or rhyme (e.g., *dig–fig*) with the targets but do not relate to the targets semantically. Clangs predominate in preschoolers and kindergarteners, but this preference is transient and fades out quickly after a year of schooling. Meanwhile, semantic associations show a sharp increase (Cronin, 2002). A shift from phonological to semantic dominance suggests that children abandon a primitive sound-based organization in favor of a more advanced meaning-based organization. However, the heightened attention to sound properties during preschool and kindergarten may be, in part, due to the intensive phonological awareness training that co-occurs with this age period (Justice, 2006).

Finally, some associations do not bear perceivable relations to the targets. These cases may be underscored by an absence of the target word node in the semantic network, an absence of links between related nodes in the network, or perhaps links so tenuous that relevant nodes are inaccessible by the spread of activation. As a result, the responder may succumb to interferences by naming things in the environment, perseverating on a previous response, or producing a random response. During development, the number of both form-based (i.e., clangs) and unrelated responses decreases and the number of semantic responses increases (Cronin, 2002; Entwisle, 1966; Sheng, 2007).

Lexical Semantic Development in Children With SLI

In laboratory-based training studies, children with SLI demonstrate difficulties learning words. Such difficulties are seen in incidental learning contexts in which children are tested on word comprehension and production after a minimal number of exposures to target words (Dollaghan, 1987; Rice, Buhr, & Nemeth, 1990; Rice, Buhr, & Oetting, 1992) and in extended word learning paradigms in which children are taught novel words with didactic input and numerous practice opportunities (Gray, 2003, 2004, 2005; Kiernan & Gray, 1998).

In particular, previous studies have indicated poor learning of the semantics of new words in children with SLI. For example, Alt and colleagues (Alt & Plante, 2006; Alt, Plante, & Creusere, 2004) found poorer learning of semantic attributes (i.e., color, pattern, eyes, animacy) of novel objects in children with SLI than in age-matched peers. Nash and Donaldson (2005) found inferior learning of the meanings of low-frequency real words (e.g., *polka*, *gauntlet*). Munro (2007) used a foreign-language teaching paradigm to examine word learning in children with and without SLI. She presented children with novel names (e.g., *jum*) for known referents (e.g., *bird*) from a puppy language over a period of 8 weeks. The novel words were presented with pictures and in sentences that aimed to enrich semantic representations (e.g., "This is a *jum*,""A *jum* flies,""A *jum* has wings"). To measure semantic learning, Munroe elicited word associations with the newly learned words as stimuli. She found that the typically developing children showed a significantly higher increase in the proportion of semantic associations, which included semantic (e.g., *jum–kookaburra*, *jum–flies*) and translation (e.g., *jum–bird*) responses, from pretraining to posttraining than the children with SLI. In addition, the typically developing children showed a prevalence of semantic associations over other response types posttraining. In the children with SLI, clangs and unrelated associations were both more frequent than semantic associations posttraining.

Given the SLI children's weakness in semantic learning, it is logical to predict that these children will have impoverished semantic representations for words stored in their long-term memory. Impoverished semantic representations may, in turn, render these words more difficult to retrieve. Such a link was demonstrated by McGregor and colleagues (McGregor & Apel, 2002; McGregor, Newman, Reilly, & Capone, 2002). In these studies, the children were asked to name, define, and draw pictures for the same target words. Errors in naming were associated with definitions containing few information units and drawings of poor quality, whereas successful naming was seen for words that contained many accurate details in both defining and drawing.

If there is a link between word retrieval and richness of semantic representation, one would expect that children who have known deficits in word retrieval to demonstrate poor semantic knowledge. Studies involving children with word-finding difficulties (WFDs) suggest that this is indeed the case. WFDs refer to the inability to find the appropriate word and the use of alternative behaviors (e.g., reformulations; repetitions; use of fillers such as *ah* or *uhm* or empty words such as *stuff* or *thing*; long pauses; and substitutions) to compensate for these difficulties (Messer & Dockrell, 2006). A survey study conducted in the United Kingdom suggests that 23% of the general population of language-impaired children also have WFDs (Dockrell, Messer, George, & Wilson, 1998). Clinically, WFDs are often diagnosed when a significant discrepancy is detected in a child's scores on a pair of conormed vocabulary tests that respectively measure word comprehension and production (German, 2000; Gray et al., 1999; Messer & Dockrell, 2006). An important caveat to this diagnostic approach is that a receptive–expressive vocabulary gap, in and of itself, is not an indicator of WFDs because typically developing children also show this pattern. Rather, at the core of this disorder are word retrieval problems that are severe enough to cause concern.

Deficits in semantic representations are implicated as a possible locus of WFDs. To illustrate, Dockrell, Messer, George, and Ralli (2003) used a definition task to examine the type of information mapped in the semantic networks of 6- and 7-year-old children with WFDs. They found that children with WFDs were less likely to provide semantic category information in definitions of nouns in comparison to age-matched peers. Simmonds, Messer, and Dockrell (2005) used a category inclusion task (e.g., "Is this a *fruit*?") with children with WFDs (age range = 8;2 [years;months] to 11;3). Compared to age-matched peers, children with WFDs showed significant delays in the speed of recognizing category members, suggesting weakened links between words at various levels of the noun hierarchy. In general, their performance was similar to that of language-matched peers who were 2 years younger.

McGregor and Waxman (1998) examined naming errors in children with and without WFDs using a contrastive naming task. For each target picture (e.g., *rose*), the experimenters asked questions such as "Is this an *animal*/a *tree*/a *dandelion*?" to elicit labels at various levels of the noun hierarchy (e.g., "No, it'sa *plant*/*flower*/*rose*"). In comparison to age-matched peers, the children with WFDs showed a larger number of indeterminate (e.g., "I don't know") and acceptance errors (e.g., "Is this a dandelion?", "yes"), indicating that these children may not have stored enough information to discriminate between semantic neighbors. The children with WFDs also showed fewer substitution errors (e.g., *tulip* for *rose*) than the controls, indicating that these children were less able to access the correct semantic neighborhood of the target words. Together, these patterns suggest a deficit in the depth of semantic storage in children with WFDs.

Recall that children with WFDs are often able to comprehend the words they fail to produce. The ability to successfully recognize the word referent among an array of pictures indicates that the children have the word stored to some degree but not in sufficient detail to support word retrieval. Whereas inadequate phonological representation of the word is undoubtedly involved in word retrieval failures (German, 2002), the studies reviewed above suggest that a less elaborate semantic representation is also likely to contribute to these difficulties.

Individual Variability in Lexical–Semantic Learning

Children with SLI are a heterogeneous group (Bishop, 2006). Whereas significant delays in morphosyntactic ability (Rice, 2004) and phonological memory capacity (Dollaghan & Campbell, 1998) have been implicated as clinical markers of SLI, the extent to which a lexical– semantic deficit characterizes the disorder is still unclear. To this end, Gray (Gray, 2003, 2004, 2005; Kiernan & Gray, 1998) has conducted a series of studies to examine word learning in children with and without SLI. The SLI children in these studies typically have a language impairment of the phonological–syntactic type and were recruited without a priori criteria on vocabulary scores. Results indicate large variability in word learning outcomes such that some children with SLI perform well within normal limits and some children who do not have a diagnosis of SLI show poor word learning. In Kiernan and Gray (1998), 73% of the children with SLI performed within normal limits on the number of words learned. In Gray (2004), 30% of the children with SLI learned as many words as the typically developing children. In Gray (2003), 23% of the children with SLI demonstrated age-appropriate word learning outcomes. It is still inconclusive what factors account for this great variability. Several learner-internal factors, such as existing vocabulary size, richness of extant semantic storage, ability to fast map, and phonological memory have been implicated as predictors of word learning performance, reflecting the complex nature of word learning.

The Present Study

To date, we know that children with SLI have difficulty learning the semantics of words in training studies and that a subgroup of children with SLI—those with WFDs—have difficulties retrieving semantic information in definition and recall tasks. We have much to learn. What is the status of lexical–semantic organization development in children from the general SLI population (i.e., those selected without regard to vocabulary or WFDs)? Do children with SLI have deficits in the number and accessibility of semantic links? If so, what is the degree of these deficits? Do these deficits affect all children with SLI? These questions are addressed by the present study.

We hypothesize that children with SLI have deficits in lexical–semantic organization. We used the repeated word association task to test this hypothesis. We predicted that deficits in lexical–semantic organization would be manifested as fewer mature (i.e., semantic) associations and more immature associations (i.e., clangs, errors) in children with SLI than in age-matched peers. In addition to age-matched controls, we included a group of children who were matched to the SLI children on expressive vocabulary. The two comparison groups would help us to determine the degree of semantic deficit relative to age expectations and to general level of vocabulary development. Significant findings in the latter comparison may indicate the presence of extraordinary difficulties that go beyond a general delay.

To examine the accessibility of semantic information in an individual's semantic networks, we used the repeated word association task and elicited 3 associations to each of 48 stimuli. Our own research using this paradigm indicated a decrease in semantic responses and a simultaneous increase in unrelated responses across multiple elicitations in typically developing children whose mean age was 7 or 8 years (Sheng et al., 2006; Sheng, Bedore, & Peña, 2008). Clang responses were at floor in these two studies possibly because the participants had passed the developmental stage when sound-based features are especially salient. Because the existing linkage in the semantic system is sparse in children with SLI, these children will show a smaller number of semantic responses, and this deficit is predicted to surface in the very first trial. With regard to the spread of semantic activation over time, there are two possibilities. First, an impaired system may show the same activation pattern as an intact system, although the slopes of the decrease in semantic associations may vary. Alternatively, the children with SLI may show a qualitatively different pattern in that semantic associations may stay constant or even increase over trials. In this latter case, an analysis of nonsemantic response types will clarify the salience of other relationships or response strategies. For instance, the SLI children may start out with many clang associations due to a preference for sound-based organization that is characteristic of young children. As they run out of sound associations in later trials, semantic responses may occur more often.

Finally, given the wide individual differences in word learning outcomes in the general SLI population, we are interested in the extent to which lexical–semantic organization skills differ among the children with SLI and the factors associated with this variation.

Method

Participants

Three groups of 14 children participated in this study: children with SLI, typically developing children who were matched to the SLI group on chronological age (AM), and typically developing children who were matched to the SLI group on expressive vocabulary (VM). Within the SLI group, there were 12 boys and 2 girls; within the AM group, there were 6 boys and 8 girls; within the VM group, there were 7 boys and 7 girls. All children were monolingual speakers of English with normal hearing (with a passing performance on a pure-tone hearing screening conducted according to guidelines of the American Speech-Language-Hearing Association, 1990) and normal or corrected-to-normal vision (according to parent report). Except for 2 cases (1 child in the SLI group was Caucasian / Latino, and 1 child in the AM group was Caucasian /Asian), all children were of Caucasian background. The ethnic distribution in this sample is reflective of the ethnic makeup of native English speakers in Iowa City, IA, and its surrounding areas, where the data were collected.

Descriptive information about the participants is presented in Table 1. Each child in the SLI group matched a child in the AM group by ±3 months. The mean ages of the SLI and AM groups were 7;2 (range = 6;1–8;6) and 7;3 (range = 6;0–8;7), respectively. Each child in the SLI group matched a child in the VM group by ±6 points in raw score on the Expressive Vocabulary Test (EVT; Williams, 1997). This 6-point difference was close to the standard deviation value (5 raw score points) on this test for children of this age. The mean age for the VM group was 5;7 (range = 5;0–7;0). The 5- to 8-year age range was of interest because previous studies show that children in this age period shift their attention from form-based relations to semantic relations between words (Cronin, 2002; K. Nelson, 1977).

The SLI group members met the following criteria to verify their status as SLI: (a) current enrollment in special service for treatment of oral language impairments; (b) absence of social, emotional, or psychiatric problems (via parent report); (c) a score of 80 or higher on the Matrices subtest of the Kaufman Brief Intelligence Test (K–BIT; Kaufman & Kaufman, 2003); and (d) a score of 1.3 *SD*s (approximately the 10th percentile, following the recommendations of Paul, 1995) below the mean or poorer on at least one of three diagnostic tests: the Repetition of Nonsense Words subtest of the Developmental Neuropsychological Assessment (Korkman, Kirk, & Kemp, 1998), the Structured Photographic Expressive Language Test—Second Edition or Preschool Second Edition (SPELT–II; Werner & Kresheck, 1983, or SPELT–P2; Dawson et al., 2005), or the Test of Narrative Language (Gillam & Pearson, 2004). This combination of diagnostic tests was chosen due to the heterogeneity of the SLI population (Bishop, 2006) and our desire to recruit from the SLI population broadly defined and without regard to vocabulary or word-finding abilities.

Lower maternal education and (within-normal limits but lower) nonverbal IQ are highly characteristic of children with SLI (see Bishop, 1992; Leonard, 1998; Plante, 1998; Tomblin et al., 1997). Thus, not surprisingly, the SLI group was not well matched to the comparison groups in terms of years of maternal education, $F(2, 39) = 5.76$, $p = .006$, or nonverbal IQ, $F(2, 39) = 3.89$, $p = .03$ (see Table 1 for means). To avoid potential confounds, we preceded the data analysis of interest with an analysis of the effects of years of maternal education and nonverbal IQ scores on the children's word association performance.

Stimuli

The stimuli included 24 nouns and 24 verbs that stand for concrete objects or actions. The nouns were *bridge*, *broom*, *cow*, *desk*, *dog*, *drawer*, *duck*, *feather*, *foot*, *fox*, *frog*, *goat*, *gun*, *hat*, *kite*, *pillow*, *saddle*, *snake*, *sock*, *spoon*, *tree*, *turtle*, *window*, and *zipper*. The verbs were *carry*, *clap*, *count*, *crawl*, *cry*, *dive*, *drive*, *eat*, *give*, *hide*, *kick*, *kneel*, *lick*, *push*, *read*, *run*, *sing*, *sit*, *smile*, *squeeze*, *sweep*, *swim*, *whisper*, and *yawn*. Table 2 presents several characteristics of the stimuli. Age of acquisition information was gathered from 14 adult monolingual English speakers following the procedures of Carroll and White (1973). With one exception, all the words had an estimated age of acquisition of under 5 years. The exception was the word *saddle*, which was estimated to be acquired at 5.3 years of age. Familiarity rating was obtained from the Hoosier Mental Lexicon (Nusbaum, Pisoni, & Davis, 1984). All the words had a familiarity rating of 6.5 or higher on a 7-point scale. Word frequency values were gathered from Moe, Hopkins, and Rush (1982). Semantic set size refers to the number of words that are frequently associated with a given word. A semantic set size of a word is determined through a discrete association task (D. L. Nelson, McEvoy, & Schreiber, 1998). Only responses reported by 2 or more participants were counted as neighbors of a given word. All words but clap were found in the Nelson et al. word association norms.

A female native English speaker with a standard American accent recorded the stimuli using a Marantz Professional (Model PMD680/U1B) digital recorder in a soundproof booth. The speaker wore an Audio-Technica ATM75 condenser microphone placed approximately 3 in. from her mouth during recording. The stimuli were processed and segmented into individual sound files using Praat version 4.3.31 (Boersma & Weenink, 2005). Intelligibility of the spoken words was verified by asking three adults to listen to and write down the words. The listeners correctly identified all words.

Procedures

The auditory stimuli were imported into E-Prime (Psychology Software Tools, 2002) and presented, one at a time, via a built-in computer speaker. Children were invited to play a word game and asked to say the first word that came to mind when hearing a prompt. To help children understand the game, the examiner prompted the children with the words *mom* and *birthday* and provided examples of semantic associations to these prompts. Following the instruction, a short practice using the words *moon*, *grass*, *cut* and *dig* was given to the children. To demonstrate that the items would be repeated, the words *moon* and *cut* were presented a second time. During practice, the examiner provided noncontingent feedback and encouraged only single-word responses. All children showed understanding of the word game during practice and spontaneously provided instances of semantic responses.

Children were seated by a table facing the side of a laptop computer. An examiner sat by the child and faced the computer screen. The volume of the auditory stimuli was adjusted to a comfortable level for each participant. The examiner set the pace of the presentation by pressing the “Enter” key on the computer. Before each trial, a 1,000-Hz alerting tone was played for 200 ms, followed by a 500-ms blank interval and then by the auditory word. In the event that the child repeated his or her previous responses, the examiner reminded the child to provide a new response each time. The examiner wrote down the responses and recorded the session with a digital audio recorder.

The list of 48 words was administered to the participants in four parts, each containing 12 words. Presentation of the four parts was counterbalanced across children. In each part, the child responded to a 12-item list, in its entirety, three times, with intervening short breaks between each repetition of the list. The 12 words were randomized anew for each of the three administrations and presented in the same order across children.

Coding

Association responses were coded into three categories: semantic, clang, or errors. Semantic associations included categorical (e.g., *dog–animal*, *cat*, *collie*; *run–exercise*), functional (e.g., *hat–wear*), descriptive (e.g., *dog–furry*, *run–fast*), thematic (e.g., *dog–leash*), causal (e.g., *lick–wet*), part–whole (e.g., *dog–tail*), or syntactic (e.g., *give–back*) relationships. Clang associations were words or made-up words that alliterated or rhymed with the prompts but that had no semantic relation with the prompts (e.g., *carry–carrot*, *broom–zoom*, *window–hindow*). Errors included no responses, repetitions of the prompts, inflections of the prompts (e.g., *foot–feet*, *tree–trees*, *swim–swam*, *push–pushed*), or words that bore no perceivable relation to the prompts (e.g., *spoon–Disney*).

Reliability

Reliability of transcription was verified by having a research assistant listen to audio-recordings of 10% of the samples and write down the child’s responses verbatim. Point-to-point agreement averaged 98.03% and ranged from 95.83% to 100%. To check for reliability of coding, a second coder blind to the identity of the children independently coded three samples from each group. Point-to-point agreement averaged 95% and ranged from 92% to 99%.

Results

Considering the Effects of Potential Confounds

We first examined the effects of maternal education and nonverbal IQ on children’s production of semantic word associations. A general linear model was set up in which maternal education and nonverbal IQ were entered as continuous predictors, group was entered as a categorical predictor, and the proportion of semantic associations served as the dependent variable (with elicitation trial as a repeated measure). The effect of maternal education was not significant, $F(1, 37) = .03$, $p = .87$, nor was the effect of nonverbal IQ, $F(1, 37) = .97$, $p = .33$. The effect of group approached significance, $F(2, 37) = 2.73$, $p = .08$. Given the lack of influence of maternal education and nonverbal IQ scores on our dependent measure, we removed these covariates in the following analyses to increase power and parsimony of the statistical model.

Statistical Approach

The statistical analysis comprised a mixed-model analysis of variance (ANOVA) conducted by participant (*F1*), with group (SLI, AM, VM) and trial (1, 2, 3) as independent variables and proportions of responses that were semantic as the dependent variable. The results were further analyzed via a mixed-model ANOVA conducted by item (*F2*), with group and trial as independent variables and the proportions of children that produced semantic responses as the dependent variable. All significance tests were two-tailed. For all significant findings, we report effect size (η_p^2), or the proportion of the effect + error variance that is attributed to the effect, and power.

Analysis by participant and by item ensured that results were robust when averaged across individual words and when averaged across individual participants, respectively. We chose semantic responses as the sole dependent variable of interest, as a higher use of (mature) semantic responses necessarily implies a lower use of (immature) clang and error responses. To run additional analyses that used clangs and errors as dependent variables would have inflated the risk of a Type I error. We did, however, conduct a descriptive analysis of clang and error responses to determine variations in their use between groups and across trials.

Semantic Associations

Group effect—The main effect of group was significant, *F1*(2, 39) = 4.98, *p* =.01, η_p^2 =. 20, *power* =.78; *F2*(2, 94) = 147.24, *p* <.001, η_p^2 = .76, *power* = 1.0. Tukey's honestly significant difference post hoc comparisons in the by-participant analyses revealed that the children with SLI (*M* = .57, *SD* = .29) produced fewer semantic associations than the AM children (*M* = .85, *SD* =.13), *p* < .01, whereas the VM children (*M* = .69, *SD* = .24) did not differ significantly from either group (see Figure 1 for by-participant results). Post hoc tests of the main effect of group by item showed that the proportion of children who gave semantic associations was higher in the AM group (*M* = .85, *SD* = .06) than in the VM group (*M* = .70, *SD* = .10), which was higher than the proportion in the SLI group (*M* = .61, *SD* = .10), *p*s <. 001.

Trial effect—The main effect of trial was significant, *F1*(2, 78) = 11.77, *p* < .001, η_p^2 = . 23, *power* = 1.0; *F2*(2, 94) = 10.75, *p* < .001, η_p^2 = .19, *power* = .99, with semantic associations being more prevalent in the first trial (*F1*: *M* = .76, *SD* = .27; *F2*: *M* = .76, *SD* = .06) than in the second (*F1*: *M* = .69, *SD* = .28; *F2*: *M* = .71, *SD* = .10) and third (*F1*: *M* = . 66, *SD* = .24; *F2*: *M* = .69, *SD* = .10) trials, Trial 1 > Trial 2 = Trial 3, *ps* < .005. The by-participant results are presented in Figure 2.

Group × Trial interaction—The interaction between group and trial was significant, *F1*(4, 78) = 3.33, *p* = .01, η_p^2 = .15, *power* = .82; *F2*(4, 188) = 11.18, *p* < .000, η_p^2 = .19, *power* = 1.0. According to follow-up tests in the by-participant analyses, the age-mates produced more semantic associations than the SLI children in the first, AM: *M* = .91, *SD* = . 10; SLI: *M* = .60, *SD* = .33; *F*(2, 38) = 4.82, *p* = .01, η_p^2 = .20, *power* = .77, and second trials, AM: *M* = .84, *SD* = .16; SLI: *M* = .53, *SD* = .32; *F*(2, 38) = 3.56, *p* = .04, η_p^2 = .16, *power* = .63, AM > SLI, *p*s < .01, but not in the third trial, AM: *M* = .78, *SD* = .18; SLI: *M* = .59, *SD* =.25; *F*(2, 38) = 2.81, *p* = .07. In addition, semantic associations decreased significantly from Trial 1 to Trial 3 in both the AM, Trial 1: *M* =.91, *SD* = .10; Trial 3: *M* = . 78, *SD* =.18; *F*(2, 26) = 8.28, *p* <.01, η_p^2 = .39, *power* =.94, and the VM, Trial 1: *M* =.76, *SD* = .25; Trial 3: *M* =.61, *SD* = .25; *F*(2, 26) = 16.21, *p* < .001, η_p^2 = .55, power = 1.0, groups, Trial 1 > Trial 3, *p*s < .005, but stayed stable across trials for the SLI group, *F*(2, 26) = 1.37, *p* = .27. These patterns are shown in Figure 3.

According to follow-up tests in the by-item analyses, the three groups differed from each other in the proportion of children who produced semantic associations in the first, AM: *M* = .91, *SD* =.07; VM: *M* = .76, *SD* = .11; SLI: *M* = .59, *SD* = .10; *F*(2, 94) = 163.95, *p* < .001, η_p^2 = .78, *power* = 1.0, and second trials, AM: *M* =.84, *SD* = .10; VM: *M* =.70, *SD* = .13; SLI: *M* = .58, *SD* = .13; *F*(2, 94) = 88.94, *p* < .001, η_p^2 = .65, *power* = 1.0, AM > VM > SLI, *p*s < .001; by the third trial, the VM (*M* =.64, *SD* =.15) and SLI (*M* = .64, *SD* = .19) groups converged and both were lower than the AM group (*M* = .79, *SD* = .11), *F*(2, 94) =

18.27, p <.001, $\eta_p{}^2$ =.28, *power* = 1.0, AM > VM = SLI, *p*s < .001. In addition, for both AM, $F(2, 94) = 20.36$, p <.001, $\eta_p{}^2$ = .30, *power* = 1.0, and VM, $F(2, 94) = 15.39$, p <.001, $\eta_p{}^2$ = .25, *power* = 1.0, groups, the proportion of children who responded semantically decreased significantly across trials (Trial 1 > Trial 2 > Trial 3, *p*s < .05); for the SLI children, the proportion increased from Trial 2 (M = .58, SD =.13) to Trial 3 (M =.64, SD =. 19), $F(2, 94) = 3.15$, $p < .05$, $\eta_p{}^2$ = .06, *power* = .59, Trial 2 < Trial 3, $p < .05$. These patterns are presented in Figure 4.

Summary—There was a significant discrepancy between the SLI and the AM children in the production of semantic associations. There was also a difference between the SLI and the VM children but only in the by-item analyses. Whereas semantic associations decreased over trials in the AM and the VM children, in the children with SLI these responses stayed stable across trials when viewed by participant and showed significant gains when viewed by item.

Nonsemantic Associations

Given that children with SLI produced fewer semantic responses than their peers, we sought to determine whether their nonsemantic responses were primarily clangs or errors (see Table 3). It is apparent that children with SLI produced more clangs than their age-mates and more errors than their age-mates and vocabulary mates (see also Figure 1). Clangs declined slightly across trials for the SLI group and remained relatively stable for the AM and VM groups (see Table 3). In contrast, errors increased across trials and did so in a fairly equivalent fashion for each group (see Table 3).

Good and Poor Responders Within the SLI Group

The finding of lower performance of the SLI group relative to the VM group in the by-item analyses suggested that the children with SLI had semantic deficits that exceeded their overall vocabulary delays. However, these comparisons were based on group means. Before concluding that children with SLI have extraordinary semantic deficits, we checked to see whether the group differences were skewed by individual performances.

Using the mean of semantic associations in the VM children as the cutoff (.69), we divided the SLI children into a group of good responders (n = 6), who scored above the VM group mean, and a group of poor responders (n = 8), who scored below the mean of the VM children. As seen in Table 4, the good and poor responders differed in the proportion of semantic associations generated, $t(12) = 5.72$, $p < .0001$, $d = 3.27$; age, $t(12) = 3.81$, p = . 002, $d = 2.02$; standardized expressive vocabulary score, $t(12) = 2.90$, $p = .01$, $d = 1.61$; and the gap between receptive and expressive vocabulary scores, $t(12) = -.2.18$, $p = .05$, d = 1.22. The good responders were older, had larger expressive vocabularies, and showed a smaller gap between receptive and expressive vocabularies than the poor responders. To further examine the receptive–expressive vocabulary discrepancy, we compared each child's standard scores on the Peabody Picture Vocabulary Test—III (Dunn & Dunn, 1997) and the EVT and determined if the gap was within 1 SD, or 15 points. The 6 good responders all had a gap of less than 15 points, whereas 6 of the 8 poor responders had a large gap of more than 15 points, $\chi^2(1) = 7.88$, $p = .005$. In all 6 cases, receptive vocabulary was considerably larger than expressive vocabulary.

Finally, we looked to see if the good and poor responders demonstrated similar profiles across trials. A repeated measure ANOVA yielded a significant interaction between trial and responding status (good vs. poor), $F(2, 24) = 3.50$, $p < .05$, $\eta_p{}^2$ = .23, *power* = .60. Follow-up tests revealed a significant decrease of semantic associations from Trial 1 (M = .91, SD = .07) to Trial 3 (M = .79, SD = .11) in the good responders, $F(2, 10) = 7.03$, $p = .01$, $\eta_p{}^2$ =.

58, *power* = .83, and a lack of significant change across trials in the poor responders, $F(2, 14) = 2.21$, $p = .15$.

Good and Poor Responders Among the Typically Developing Children

To facilitate interpretation of the data from the SLI children, we performed individual analyses within the typically developing children. Using the mean proportion of semantic association in the VM group as the cutoff, the 28 typically developing children were divided into a group of 21 good responders and a group of 7 poor responders. The poor responders included 5 children from the VM group and 2 children from the AM group. Demo-graphic information and standard test performance of these two groups are presented in Table 5. Because of the unequal size of the groups, *t* tests were not conducted. However, inspection of the means revealed that the two groups were comparable in age, maternal education, nonverbal IQ, receptive vocabulary, nonword repetition scores, proportion correct on the SPELT–II, and scores on the Test of Narrative Language. On the other hand, there were large between-group differences on expressive vocabulary and the receptive–expressive vocabulary gap.

When examined individually, 4 of the 7 poor responders had a large receptive–expressive vocabulary gap (≥15 points), whereas only 4 out of the 21 good responders had a gap this size, $\chi^2(1) = 3.73$, $p = .053$. In all cases, receptive vocabulary was larger than expressive vocabulary. The reverse was never true as none of the children had a significantly larger expressive than receptive vocabulary.

Last, we examined the accessibility of semantic associations across trials in good and poor responders. Semantic associations decreased across trials in both good (Trial 1: *M* = .93, *SD* = .07; Trial 2: *M* = .87, *SD* = .09; Trial 3: *M* =.79, *SD* = .14) and poor (Trial 1: *M* = .56, *SD* = .22; Trial 2: *M* =.47, *SD* = .22; Trial 3: *M* = .40, *SD* =.18) responders.

Discussion

We posed four goals in this study of lexical–semantic organization. First, we tested the hypothesis that children with SLI have deficient lexical–semantic organization in comparison to age-matched peers. Second, we aimed to determine the degree of this deficit by comparing children with SLI to their vocabulary peers. Third, we examined the accessibility of semantic links by focusing on the rate of semantic and nonsemantic responses over multiple trials. Fourth, we investigated within-group variability in performance on this task of lexical–semantic organization. We now address each of these questions in turn.

Number of Semantic and Nonsemantic Links

Figure 1 presents a summary of association performance by the three groups of children. In comparison to their age-mates, children with SLI showed a depressed level of semantic associations and an elevated level of less mature responses that were either related by form (clangs) or unrelated (errors) to the prompts. These findings confirmed our hypothesis that children with SLI have deficits in lexical–semantic organization. These findings are also consistent with existing studies demonstrating deficits in semantic learning (Alt & Plante, 2006; Alt et al., 2004; Gray, 2003, 2004, 2005; Munro, 2007; Nash & Donaldson, 2005) and semantic processing (Dockrell et al., 2003; McGregor & Waxman, 1998; McGregor et al., 2002; Simmonds et al., 2005) in children with SLI. In the by-item analyses, there were signs of delay in children with SLI even in comparison to their younger vocabulary peers. These were manifested as fewer semantic responses and more errors. These findings, although preliminary, suggest that the degree of deficit in lexical–semantic organization exceeds that expected given general vocabulary level.

Munro (2007) has provided some insight into how this deficit in organization comes about. Even after 8 weeks of training meant to enhance semantic knowledge of new word forms, children with SLI were less likely than their unaffected peers, who had the same number and type of training experiences, to recall semantic associates of those newly learned words. Even if one assumes that, with additional training, the children with SLI would eventually have reached a level comparable to their peers, in the very least the time course for the emergence of robust semantic connections within the lexicons of children with SLI is prolonged. Because semantic links between words encompass a myriad of categorical, physical, functional, causal, thematic, syntactic, and collocational knowledge, the building of a sophisticated semantic network represents a formidable task for those, like children with SLI, whose language learning is slow.

We note that the deficit in semantic organization is rather subtle relative to the vocabulary peers. In general, the by-item analyses afforded more power for detection of subtle differences than the by-participant analyses; this is because there were more items than participants and because there was more variability between the means for each participant than between the means for each item (see error bars in Figure 1, for example). The important point is that children with SLI showed deficits in lexical–semantic organization in comparison to children who were, on average, 19 months their junior and whose expressive vocabularies were roughly similar. Therefore, the problem was not likely one of missing words in the lexicon but of missing or fragile links between words.

The Accessibility of Links

The three groups of children showed three distinct performance profiles across trials: For the AM children, semantic responses decreased, errors increased, and clangs were always rare; for the VM children, semantic responses decreased, errors increased, and clangs were sizable and consistent; for the SLI children, semantic responses were consistent (albeit low in number), errors increased, and clangs decreased.

Although all children showed a predominance of semantic associations over other response types (see Figure 1), only the AM and VM children showed a decline in these responses over trials. This decrement in the number of semantic responses is consistent with the assumption that semantic activation becomes attenuated over time as it travels outward from the node of origin (Collins & Loftus, 1975). It appears that in an intact system, spreading semantic activation is initially of maximal strength. As the strength of activation abates, fewer semantic links can be accessed and nonsemantic associations take over. These nonsemantic association responses may be attributed to sound-based relations or noises in the system (i.e., perseverations, unrelated items).

Compared to the peak level of semantic responses seen in the typically developing children, the SLI children showed a dampened and stable level of semantic responding across trials. For these children, the spread of semantic activation was significantly weaker and operated in an environment with a high level of noise (errors) and greater salience of primitive organizational principles (clangs). The concurrent decline in clang responses across trials in the SLI children (see Table 3) suggested that sound properties of the prompts were highly activated initially but became gradually dampened. These children may be at a developmental stage in which sound similarity between words is about to fade out as a highly salient organizational principle. The VM children, on the other hand, did not show a decrease in clangs. These children, due to their young age, may be at a stage in which sound similarity is at its prime as an organizational and retrieval strategy. Alternatively, the salience of clangs in these children may be a result of the therapy or classroom activities that focus on emergent literacy skill development. Some of the younger children with SLI and many of the VM children were likely receiving instructions to facilitate the development of phonemic awareness, and this may have inflated the frequency of clangs.

Within-Group Variability in Lexical–Semantic Organization

Gray (2003, 2004) suggested that children with SLI vary widely in word learning potentials. The present investigation attested to this view. An examination of individual children's performance in the SLI group yielded a group of good responders who reached or surpassed the mean performance of the younger vocabulary peers and a group of poor responders who scored below the mean performance of younger peers. The good responders performed within age expectations, both in terms of the overall number of semantic associations and in terms of the pattern of semantic activation across trials. The good responders also achieved scores that were close to the population mean on measures of receptive and expressive vocabulary. Therefore, these children's impairment lay in other domains of language, such as phonological memory, morphosyntax, or narrative discourse. The poor responders were comparable to the good responders in maternal education, phonological memory capacity, narrative discourse skills, nonverbal IQ, and receptive vocabulary. What distinguished them from the good responders were the considerably lower expressive vocabulary and the significant receptive–expressive vocabulary discrepancy.

This is reminiscent of WFDs, which are diagnosed when children have significant difficulties with retrieving words accompanied by a significantly larger receptive than expressive vocabulary (German, 2000; Gray et al., 1999). Studies on children with WFDs have implicated break-downs at the semantic level as an underlying locus of the deficit (Dockrell et al., 2003; McGregor & Waxman, 1998; Simmonds et al., 2005). Our results are in agreement with these studies in suggesting that difficulties in word retrieval may be a result of impoverished long-term semantic storage (McGregor et al., 2002). In particular, our study contributes to the literature on WFDs in suggesting that the semantic networks of children with WFDs may have fewer and weaker links, which renders these children more susceptible to word retrieval failures.

Applying the same criterion, 7 of the typically developing children were identified as poor responders. Similar to the poor responders in the SLI group, these children showed a lower expressive vocabulary and a larger receptive–expressive vocabulary gap but were comparable to the good responders in all other comparisons. This profile aligns with the condition of WFDs except that the individual had otherwise normal language. Surely, word-finding problems are not restricted to children with language impairment, as all individuals occasionally experience difficulties retrieving words (Messer & Dockrell, 2006). Our result suggests that the relatively low expressive vocabulary in these children is also associated with an inadequately linked semantic network.

Finally, because the good and poor responders differed on expressive vocabulary, the argument that children with SLI show deficits in lexical–semantic organization that go beyond a general delay in vocabulary needs to be tempered. It appeared that the degree of lexical– semantic organization deficits was commensurate with the degree of vocabulary delay. The SLI children who had more severe vocabulary delays were the ones who scored below the vocabulary mates on semantic association performance.

Conclusions

The present study contributed to the literature on SLI by providing evidence for a deficit in the organization of the lexical–semantic system. The deficit is especially notable in children who have a deficit in expressive vocabulary and a gap between receptive and expressive vocabulary (i.e., WFDs). The deficit was characterized by dependence on sound-based connections between items in the lexicon and more erroneous responses, both of which suggest fewer or less-robust semantic links to support spreading activation.

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References

Alt M, Plante E. Factors that influence lexical and semantic fast-mapping of young children with specific language impairment. Journal of Speech, Language, and Hearing Research. 2006; 49:941–954.

Alt M, Plante E, Creusere M. Semantic features in fast-mapping: Performance of preschoolers with specific language impairment versus preschoolers with normal language. Journal of Speech, Language, and Hearing Research. 2004; 47:407–420.

American Speech-Language-Hearing Association. Guidelines for screening for hearing impairments and middle ear disorders. Asha. 1990; 32(Suppl. 2):17–24.

Bishop DVM. The underlying nature of specific language impairment. Journal of Child Psychology and Psychiatry and Allied Disciplines. 1992; 33:3–66.

Bishop, DVM. Uncommon understandings. Psychology Press; East Sussex, United Kingdom: 1997.

Bishop DVM. What causes specific language impairment in children? Current Directions in Psychological Science. 2006; 15:217–221. [PubMed: 19009045]

Boersma, P.; Weenink, D. Praat: Doing phonetics by computer. Version 4.3.312005. [Computer program]. Available from www.praat.org

Brackenberry T, Pye C. Semantic deficits in children with language impairments: Issues for clinical assessment. Language, Speech, and Hearing Services in Schools. 2005; 36:5–16.

Carroll JB, White MN. Word frequency and age of acquisition as determiners of picture-naming latency. Quarterly Journal of Experimental Psychology. 1973; 23:85–95.

Collins AM, Loftus EF. A spreading activation theory of semantic processing. Psychological Review. 1975; 82:407–428.

Cronin VS. The syntagmatic-paradigmatic shift and reading development. Journal of Child Language. 2002; 29:189–204. [PubMed: 11968883]

Dawson, J.; Stout, C.; Eyer, J.; Tattersall, P.; Fonkalsrud, J.; Croley, K. Structured Photographic Expressive Language Test—Preschool Second Edition. Janelle; DeKalb, IL: 2005.

De Deyne S, Storms G. Word associations: Norms for 1,424 Dutch words in a continuous task. Behavior Research Methods. 2008; 40:198–205. [PubMed: 18411543]

De Groot AMB. Representational aspects of word imageability and word frequency as assessed through word association. Journal of Experimental Psychology: Learning, Memory, and Cognition. 1989; 15:824–845.

Dockrell JE, Messer D, George R, Ralli A. Beyond naming patterns in children with WFDs—definitions for nouns and verbs. Journal of Neurolinguistics. 2003; 16:191–211.

Dockrell JE, Messer D, George R, Wilson G. Children with word-finding difficulties—prevalence, presentation and naming problems. International Journal of Language and Communication Disorders. 1998; 33:445–454. [PubMed: 10505142]

Dollaghan C. Fast mapping in normal and language impaired children. Journal of Speech and Hearing Disorders. 1987; 52:218–222. [PubMed: 3455444]

Dollaghan C, Campbell T. Nonword repetition and child language impairment. Journal of Speech, Language, and Hearing Research. 1998; 41:1136–1146.

Dunn, LM.; Dunn, LM. Peabody Picture Vocabulary Test—III. AGS; Circle Pines, MN: 1997.

Entwisle, D. Word associations of young children. Johns Hopkins Press; Baltimore: 1966.

German, DJ. Test of Word Finding. Second Edition. Pro-Ed; Austin, TX: 2000.

German DJ. A phonologically based strategy to improve word finding abilities in children. Communication Disorders Quarterly. 2002; 23:177–190.

Gillam, RB.; Pearson, NA. Test of Narrative Language. Pro-Ed; Austin, TX: 2004.

Gray S. Word learning by preschoolers with specific language impairment: What predicts success? Journal of Speech, Language, and Hearing Research. 2003; 47:56–67.

Gray S. Word learning by preschoolers with specific language impairment: Predictors and poor learners. Journal of Speech, Language, and Hearing Research. 2004; 47:1117–1132.

Gray S. Word learning by preschoolers with specific language impairment: Effect of phonological and semantic cues. Journal of Speech, Language, and Hearing Research. 2005; 48:1452–1467.

Gray S, Plante E, Vance R, Henrichsen M. The diagnostic accuracy of four vocabulary tests administered to preschool children. Language, Speech, and Hearing Services in Schools. 1999; 30:196–206.

Justice LM. Evidence-based practice, response to intervention, and the prevention of reading difficulties. Language, Speech, and Hearing Services in Schools. 2006; 37:284–297.

Kail R, Leonard LB. Word-finding abilities in language-impaired children. ASHA Monographs. 1986; 25

Kaufman, AS.; Kaufman, NL. The Kaufman Brief Intelligence Test. AGS; Circle Pines, MN: 2003.

Kiernan B, Gray S. Word learning in a supported-learning context by preschool children with specific language impairment. Journal of Speech, Language, and Hearing Research. 1998; 41:161–171.

Korkman, M.; Kirk, U.; Kemp, S. A Developmental Neuropsychological Assessment (NEPSY). The Psychological Corporation; San Antonio, TX: 1998.

Leonard, LB. Children with specific language impairment. MIT Press; Cambridge, MA: 1998.

McClelland, JL. A connectionist perspective on knowledge and development. In: Simon, TJ.; Halford, GS., editors. Developing cognitive competence: New approaches to process modeling. Erlbaum; Hillsdale, NJ: 1995. p. 157-204.

McGregor KK. The nature of word finding errors of preschoolers with and without word-finding deficits. Journal of Speech and Hearing Research. 1997; 40:1232–1244.

McGregor KK, Appel A. On the relationship between mental representation and naming in a child with specific language impairment. Clinical Linguistics and Phonetics. 2002; 16:1–20. [PubMed: 11913029]

McGregor KK, Newman RM, Reilly RM, Capone N. Semantic representation and naming in children with specific language impairment. Journal of Speech, Language, and Hearing Research. 2002; 45:998–1014.

McGregor KK, Waxman SR. Object naming at multiple hierarchical levels: A comparison of preschoolers with and without word-finding deficits. Journal of Child Language. 1998; 25:419–430. [PubMed: 9770914]

Messer D, Dockrell JE. Children’s naming and word-finding difficulties: Descriptions and explanations. Journal of Speech, Language, and Hearing Research. 2006; 49:309–324.

Moe, A.; Hopkins, C.; Rush, T. The vocabulary of first-grade children. Charles C Thomas; Springfield, IL: 1982.

Munro, N. Unpublished doctoral dissertation. University of Sydney; Australia: 2007. The quality of word learning in children with specific language impairment.

Nash M, Donaldson ML. Word learning in children with vocabulary deficits. Journal of Speech, Language, and Hearing Research. 2005; 48:439–458.

Nelson, DL.; McEvoy, CL.; Schreiber, TA. [Retrieved May 8, 2008] The University of South Florida word association, rhyme, and word fragment norms. 1998. from www.usf.edu/FreeAssociation/

Nelson K. The syntagmatic-paradigmatic shift revisited: A review of research and theory. Psychological Bulletin. 1977; 84:93–116. [PubMed: 322183]

Nusbaum HC, Pisoni DB, Davis CK. Sizing up the Hoosier Mental Lexicon: Measuring the familiarity of 20,000 words. Research on Speech Perception Progress Report. 1984; 10:357–376.

Paul, R. Language disorders from infancy through adolescence: Assessment and intervention. Mosby; St Louis, MO: 1995.

Plante E. Criteria for SLI: The Stark and Tallal legacy and beyond. Journal of Speech, Language, and Hearing Research. 1998; 41:951–957.

Psychology Software Tools. E-Prime. Version 1.1. Author; Pittsburgh, PA: 2002. [Computer software]

Rice, M. Growth models of developmental language disorders. In: Rice, ML.; Warren, SF., editors. Developmental language disorders: From phenotypes to etiologies. Erlbaum; Mahwah, NJ: 2004. p. 207-240.

Rice ML, Buhr JC, Nemeth M. Fast mapping word-learning abilities of language-delayed preschoolers. Journal of Speech and Hearing Disorders. 1990; 55:33–42. [PubMed: 2299838]

Rice ML, Buhr JC, Oetting JB. Specific language-impaired children's quick incidental learning of words: The effect of a pause. Journal of Speech and Hearing Research. 1992; 35:1040–1048. [PubMed: 1447916]

Sheng, L. Unpublished doctoral dissertation. Northwestern University; Evanston, IL: 2007. Lexical access and semantic organization in children with specific language impairment.

Sheng, L.; Bedore, L.; Peña, ED. Lexical–semantic organization in Spanish–English bilingual children. Talk presented at the Conference on Bilingual Acquisition in Early Childhood; Hong Kong, China. Dec. 2008

Sheng L, McGregor KK, Marian V. Lexical– semantic organization in bilingual children: Evidence from a repeated word association task. Journal of Speech, Language, and Hearing Research. 2006; 49:572–587.

Simmonds, L.; Messer, D.; Dockrell, J. Exploring semantic deficits in children with WFDs. Paper presented at the 10th International Congress for the Study of Child Language; Berlin, Germany. Jul. 2005

Tomblin JB, Records NL, Buckwalter P, Zhang X, Smith E, O'Brien M. Prevalence of specific language impairment in kindergarten children. Journal of Speech, Language, and Hearing Research. 1997; 40:1245–1260.

Werner, E.; Kresheck, JD. Structured Photo-graphic Expressive Language Test—II. Janelle; Sandwich, IL: 1983.

Williams, KT. Expressive Vocabulary Test. AGS; Circle Pines, MN: 1997.

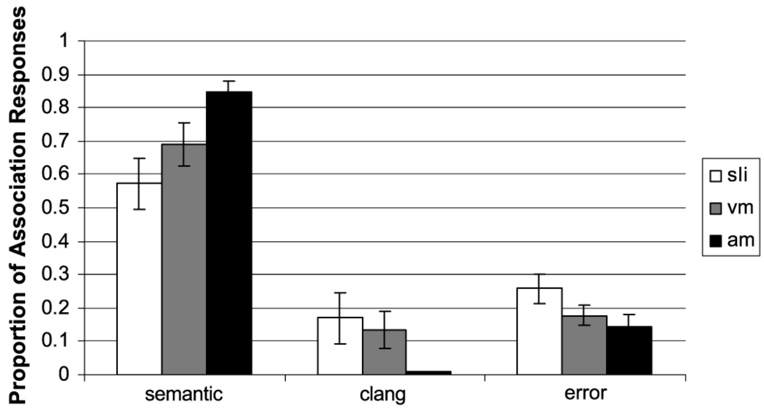

Figure 1.
Mean and standard error of association responses by group and response type.

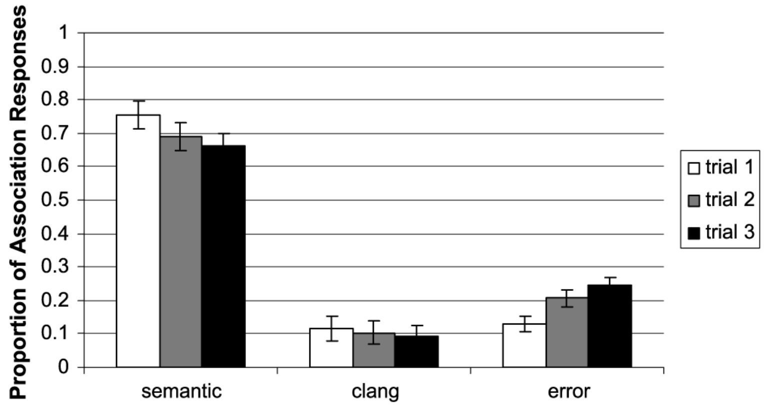

Figure 2.
Mean and standard error of association responses by trial and response type.

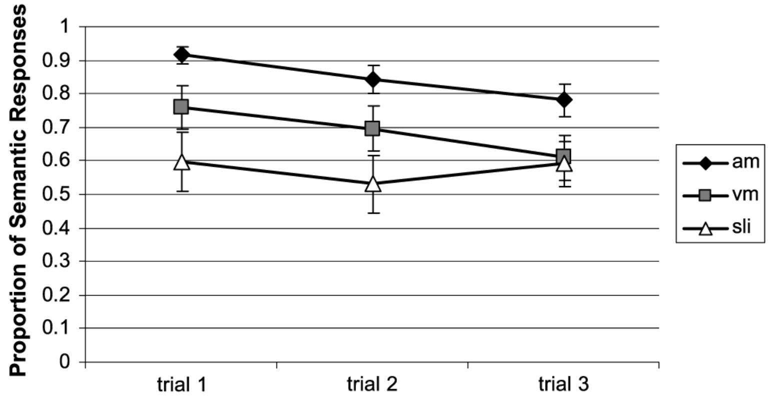

Figure 3.
Mean and standard error of semantic associations as a function of group and trial, viewed by participant.

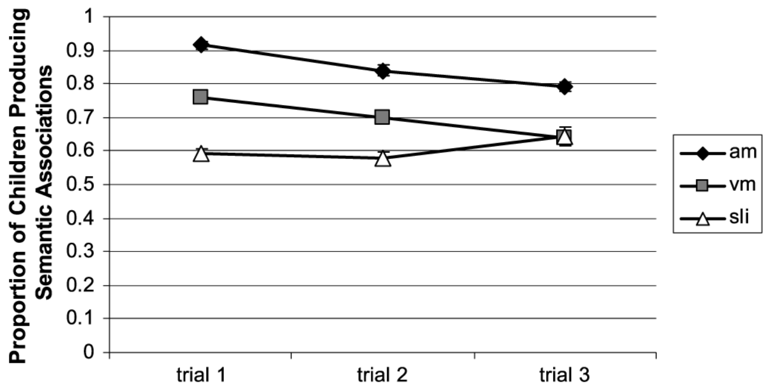

Figure 4.

Mean and standard error of semantic associations as a function of group and trial, viewed by item.

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Table 1

Group characteristics and performance on language measures.

Group	Age (years;months)	Maternal education (years)	K–BIT	EVT	PPVT–III	SPELT	NWRT	TNL
SLI								
M	7;2	14.36	95.36	86.43	97.36	.71	7.00	83.07
SD	0;10	2.10	13.67	11.06	9.36	.14	1.66	18.44
AM								
M	7;3	16.50	108.93	112.21	116.29	.95	12.71	113.50
SD	0;10	2.10	16.41	11.38	9.29	.05	2.49	15.31
VM								
M	5;7	16.79	102.29	106.50	114.07	.83	11.57	106.55
SD	0;7	2.01	6.45	10.55	10.51	.08	1.95	10.55

Note. K–BIT = standard scores on the Matrices section of the Kaufman Brief Intelligence Test; EVT = standard scores on the Expressive Vocabulary Test; PPVT–III = standard scores on the Peabody Picture Vocabulary Test—III (Dunn & Dunn, 1997); SPELT = proportion correct on the Structured Photographic Expressive Language Test—Second Edition or Preschool Edition (proportion correct was used because standard scores lower than 66 were not provided in the manual, rendering standard scores unavailable for 7 children in the specific language impairment [SLI] group); NWRT = standard scores on the Repetition of Nonsense Words subtest of the Developmental Neuropsychological Assessment (*M* = 10, *SD* = 3); TNL = standard scores on the Test of Narrative Language. Four children in the age-matched (AM) group and 3 children in the vocabulary-matched (VM) group did not take this test; however, they passed all the other tests, and there were no concerns about their language development.

Table 2

Mean, standard deviation, and range for the characteristics of the 48 stimulus words.

Characteristic	*M*	*SD*	Minimum	Maximum
Age of acquisition[a]	2.96	.86	1.62	5.31
Familiarity[b]	6.96	.09	6.67	7.00
Word frequency[c]	1.30	.69	0	2.59
Semantic set size[d]	13.26	4.30	4.00	21.00

[a]Based on estimates from 14 adult native speakers of English.

[b]Based on a scale from 1 to 7 (Nusbaum et al., 1984).

[c]Log frequency value based on Moe et al. (1982).

[d]Number of semantic associations based on Nelson et al. (1998); these values were thus derived from 47 words because the word *clap* was not in the Nelson et al. norms.

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Table 3

Mean proportion (standard error) of clangs and errors by participant group and elicitation trial.

	Clangs				Errors			
Group	**Trial 1**	**Trial 2**	**Trial 3**	**All trials**	**Trial 1**	**Trial 2**	**Trial 3**	**All trials**
SLI								
F1	.20 (.09)	.18 (.08)	.13 (.06)	.17 (.08)	.20 (.05)	.29 (.05)	.28 (.04)	.26 (.04)
F2	.20 (.01)	.16 (.01)	.08 (.01)	.15 (.01)	.20 (.02)	.26 (.02)	.27 (.02)	.25 (.01)
VM								
F1	.14 (.06)	.12 (.06)	.15 (.05)	.13 (.06)	.10 (.03)	.18 (.03)	.25 (.04)	.18 (.03)
F2	.14 (.01)	.12 (.01)	.13 (.02)	.13 (.01)	.10 (.01)	.18 (.01)	.23 (.02)	.17 (.01)
AM								
F1	.01 (.00)	.01 (.00)	.01 (.00)	.01 (.00)	.07 (.02)	.15 (.04)	.21 (.05)	.14 (.03)
F2	.01 (.00)	.01 (.00)	.01 (.00)	.01 (.00)	.07 (.01)	.15 (.02)	.20 (.02)	.14 (.01)
All groups								
F1	.12 (.04)	.10 (.04)	.09 (.03)	.10 (.03)	.13 (.02)	.21 (.03)	.25 (.02)	.19 (.02)
F2	.12 (.01)	.10 (.01)	.08 (.01)	.10 (.01)	.13 (.01)	.20 (.01)	.23 (.01)	.19 (.01)

Note. *F1* = by-participant means. *F2* = by-item means.

Table 4

Semantic performance profile and background characteristics for individual children in the SLI group.

ID	Semantic association[a]	Age (months)	Maternal education (years)	K–BIT	PPVT–III	EVT	PPVT–EVT[b]	SPELT	NWRT	TNL
Good responders										
1	.95	102	13	80	101	95	6	< 66	7	85
2	.88	97	16	110	98	84	14	69	6	70
3	.86	81	16	90	104	96	8	75	9	79
4	.84	90	13	94	106	103	3	95	6	106
5	.83	97	12	112	94	99	−5	89	6	100
6	.72	99	16	80	80	89	−9	95	10	61
M (*SD*)	.85 (.08)	94.33 (7.63)	14.33 (1.86)	94.33 (14.05)	97.17 (9.43)	94.33 (6.86)	2.83 (8.52)	84.60 (11.95)[c]	7.33 (1.75)	83.50 (17.26)
Poor responders										
7	.56	73	18	86	101	77	24	89	5	88
8	.53	89	16	116	84	92	−8	75	7	118
9	.50	81	16	81	107	71	36	< 66	6	61
10	.46	78	12	85	102	84	18	< 66	5	91
11	.43	86	16	96	111	95	16	< 66	6	100
12	.24	74	12	104	100	71	29	< 66	8	76
13	.17	86	12	116	87	69	18	< 66	7	58
14	.03	77	13	85	88	85	3	< 66	10	70
M (*SD*)	.37** (.19)	80.50** (5.98)	14.38 (2.39)	96.13 (14.30)	97.50 (9.96)	80.50* (10.00)	17.00* (14.03)	—[d]	6.75 (1.67)	82.75 (20.46)

Note. Participants 1–6 scored above the mean of the VM group on semantic association performance and, hence, were considered good responders. Participants 7–14 scored below the mean of the VM group and were thus considered poor responders.

[a]Proportion of semantic associations.

[b]Difference in standard scores between the PPVT–III and the EVT.

[c]The mean was based on 5 children for whom standard scores were available.

[d]Mean was not available due to the large number of missing standard scores.

*A significant difference between the good and poor responders, with *p* level ≤ .05.

** A significant difference between the good and poor responders, with p level < .01.

Table 5

Means (and standard deviations) of semantic performance and background characteristics for the good and poor responders in the typically developing children.

Status	Semantic association	Age (months)	Maternal education (years)	K–BIT	PPVT–III	EVT	PPVT–EVT	SPELT	NWRT	TNL
Good	.86 (.08)	77.71 (13.64)	16.33 (1.93)	106.38 (13.26)	115.00 (10.56)	111.62 (10.69)	3.38 (10.20)	.90 (.09)	12.29 (2.26)	110.71 (14.82)
Poor	.48 (.20)	72.86 (12.75)	17.57 (2.15)	103.29 (11.43)	115.72 (7.72)	102.57 (10.37)	13.14 (7.69)	.85 (.09)	11.71 (2.43)	108.14 (9.91)