Modeling the Semantic Networks of School-Age Children with Specific Language Impairment and Their Typical Peers

Patricia J. Brooks, Josita Maouene, Kevin Sailor, and Liat Seiger-Gardner

1. Introduction

In producing language, speakers rely on semantic knowledge to access words relevant to the discourse context (Dell, 1986; Roelofs, 1992). Hence, it is important to understand how difficulties in acquiring spoken language impact the development of semantic representations necessary for efficient lexical access. Specific Language Impairment is a condition affecting approximately 7% of children, associated with language deficits that are not attributable to neurological damage, intellectual disability, or hearing impairment (Leonard, 2014). Children with SLI exhibit a slower rate of lexical acquisition and have less diverse receptive and expressive vocabularies than their peers with typical language development (TLD) (Rice, Buhr, & Nemeth, 1990; Watkins, Kelly, Harbers, & Hollis, 1995). These children often exhibit word-finding difficulties and produce speech characterized by repetitions, reformulations, pauses, and use of nonspecific words, e.g., stuff, thing (Messer & Dockrell, 2006; Nippold, 1992). Children with SLI frequently make semantic errors involving lexical substitutions, e.g., bird for ostrich; mouse for kangaroo (Lahey & Edwards, 1999; McGregor, Newman, Reilly, & Capone, 2002). Such errors have been attributed to lexical gaps (children’s lack of knowledge of specific words) or fragile, underspecified lexical representations that are not well elaborated at semantic or conceptual levels (McGregor, Friedman, Reilly, & Newman, 2002).

To isolate semantic difficulties associated with SLI, researchers have utilized priming paradigms that assess how contextual cues (i.e., previously activated words) facilitate access to semantically related words (Brooks, Seiger-Gardner, & Sailor, 2014; Girbau, 2014; Hennessey, Leitão and Mucciarone, 2010; Velez & Schwartz, 2010). These studies document weak to non-existent semantic priming in spoken-word production and recognition tasks in children with SLI, which contrasts with performance of age-matched TLD controls. The current study uses semantic network modeling to explore possible differences in

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the lexical-semantic organization in children with and without SLI. We generated a corpus of semantically related words using a repeated word association task (Elbers & van Loon-Vervoorn, 1998): school-age children were instructed to say the first word that came to mind in response to 24 cues (i.e., concrete nouns) with the list repeated four times. Based on prior research (Sheng & McGregor, 2010), we expected children with SLI to exhibit word-finding difficulties and more often produce responses that were phonologically, but not semantically, related to the cues than TLD controls.

The current study extends the prior work in two ways. First, we computed pairwise estimates of similarity and semantic distance between the cues and children’s responses, using measures derived from very large corpora of English text (Landauer & Dumais, 1997; Mandera, Keuleers, & Brysbaert, 2017). We used these estimates to evaluate the quality of children’s responses to the cues and the extent to which the semantic relatedness of their responses declined over repetitions of the list. We predicted that children with SLI would have greater difficulties generating semantically related responses to the cues, with difficulties worsening over time.

Second, we visualized the corpus of word associations using semantic-network models (Steyvers & Tenenbaum, 2005), pooling responses across participants and list repetitions to make inferences about perceived similarities between the cues based on shared associations (e.g., fly occurring in response to the cues balloon, bird, and spider). Steyvers and Tenenbaum analyzed the large-scale structure of three types of semantic networks, including word associations, and showed that they all had a small-world structure, characterized by short average path lengths between words, and strong local clustering. They proposed a model of semantic differentiation as one among many possible mechanisms of growth. To examine the repercussions of different patterns of association on network structure, we constructed separate models for SLI and TLD groups and examined the network structure formed by the shared associations and the resulting communities (how the 24 cues congregated into groups based on shared associations) with the hypothesis that the SLI network would exhibit a lesser degree of semantic differentiation than the TLD network.

2. Experimental Study
2.1. Method
2.1.1. Participants

Forty children participated in the study. Half of the children presented with SLI and the other half with TLD. Each child in the SLI group was age-matched with a child in the TLD group ± 3 months, with 11 boys and 9 girls in each group. The SLI group ranged in age from 8;0 to 10;8 (M = 9;4) and the TLD group ranged from 7;10 to 10;8 (M = 9;2). Thirteen children with SLI were

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1 In examples provided, cue words are shown in italics and responses in bold.
recruited from a private school in New York City serving children with a variety of learning difficulties; seven children with SLI and 20 TLD controls were recruited through advertisements. Children were drawn from households where American English was the primary language spoken. All children passed a hearing screening and had no speech impairments. All children exhibited non-verbal intelligence within normal limits defined by a score of 80 or above on the TONI, 2nd Edition (Brown, Sherbenou, & Johnsen, 1990) or by school records in the case of children recruited from the private school. For children with SLI recruited from the private school, the school’s speech-language pathologist confirmed the child’s diagnosis and enrollment in speech and language therapy. For children with SLI recruited through advertisements, the presence of a language impairment was determined by a composite score of 85 or lower on the CELF 3 or CELF 4 (Semel, Wiig, & Secord, 1995/2006), $M = 65$, range 48 to 85, diagnosis of a language impairment by a certified speech language pathologist, and enrollment in speech and language therapy.

2.1.2. Stimuli

The cues for the repeated word association task were 24 concrete nouns, taken from Brooks et al. (2014): balloon, bird, cake, castle, clown, cow, dog, flower, hair, hamburger, hammer, hand, horse, needle, pan, rabbit, ring, sandwich, shark, shirt, shoe, snake, spider, and train.

2.1.3. Procedure

The repeated word association task was introduced as a word game and administered by a female native speaker of English. Children were instructed to say the first word that came to mind after each word in a list. They were told that each word would be presented more than once, and that each time they heard the word, they were to provide a new answer. Children were given a short practice with the task using the cues butterfly, car, jar, and pickle. During practice, the examiner instructed children to provide only single-word responses and provided general encouragement. All children showed understanding of the word game during practice and spontaneously provided instances of semantically related responses. In the event that the child repeated a previous response to one of the cues, 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 24 cue words was administered in one of two randomized orders (counterbalanced across children within each group), with the same order used for each of four list presentations.

2.1.4. Response Coding

To examine the extent to which children experienced difficulties in generating responses to the cues, we coded responses as (1) word-finding
difficulties, (2) clangs, and (3) preservative responses. Word-finding difficulties were failures to produce any response or use of a generic response: *anything, nothing, something*, or *thing*. Clangs were as responses that were phonologically, but not semantically, related to the cue (e.g., *shirt* → *shot; balloon* → *baboon*). Perseverative responses were instances where the child reused a response made to a previous cue (e.g., *balloon* → *tree; spider* → *tree*, with the later response coded as perseverative) or use one of the cues as a response to a later cue (e.g., *hair* → *wash; clown* → *hair*, with the later response coded as perseverative).

Next, we used two computerized databases to evaluate the semantic relatedness of children’s responses to the cues, entering the cue-response pairs into each database to generate indices of relatedness. The Continuous Bag of Words (CBOW) uses semantic vectors to compute estimates of semantic distance between word pairs, with output provided in the form of cosign values (Mandera et al., 2017). Latent Semantic Analysis (LSA) uses a form of factor analysis (distributional semantics) to estimate similarity between pairs of words as a function of their co-occurrence in text (Landauer & Dumais, 1997).

Finally, we examined the extent to which children produced idiosyncratic “oddball” responses, i.e., cue-response pairs that occurred only once in the full corpus (e.g., *cow* → *hotdog; cow* → *look; cow* → *moon*).

### 2.2. Results

#### 2.2.1. General Task Difficulties

Table 1 provides the rates of word-finding difficulties as a function of group and list repetition. A mixed design ANOVA (group as a between-subjects factor, list repetition as a within-subjects factor) showed no significant effects, with only the main effect of group approaching significance, $F(1, 38) = 3.08, p = .087, \eta^2_p = .075$; SLI: $M = 2.9\%$, TLD: $M = 0.6\%$. The low rates of word-finding difficulties indicate that participants were successful in generating responses to the cues as instructed. Indeed, only four children with SLI (and none with TLD) exhibited word-findings difficulties on more than 5% of trials.

<table>
<thead>
<tr>
<th>List Repetition</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<tbody>
<tr>
<td>SLI</td>
<td>1.5%</td>
<td>2.6%</td>
<td>3.5%</td>
<td>4.1%</td>
</tr>
<tr>
<td>(5.6)</td>
<td>(6.4)</td>
<td>(8.1)</td>
<td>(9.2)</td>
<td></td>
</tr>
<tr>
<td>TLD</td>
<td>0.7%</td>
<td>0.7%</td>
<td>0.2%</td>
<td>0.9%</td>
</tr>
<tr>
<td>(1.6)</td>
<td>(2.2)</td>
<td>(0.9)</td>
<td>(1.8)</td>
<td></td>
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</tbody>
</table>
Table 2 provides percentages of clang responses as a function of group and list repetition. A mixed design ANOVA revealed significant main effects of group, $F(1, 38) = 5.82, p = .021$, $\eta^2_p = .133$; SLI: $M = 3.4\%$, TLD: $M = 0.7\%$, and repetition, $F(3, 114) = 2.94, p = .036$, $\eta^2_p = .072$, with a non-significant group × repetition interaction, $F(3, 114) = .96, p = .412$. Children with SLI produced more responses that were phonologically, but not semantically, related to the cues, with clangs becoming more common as the task progressed. Nevertheless, clangs were infrequent, with only four children with SLI (and none with TLD) producing clangs on greater than 5\% of trials.

Table 2. Mean percentages of responses coded as clangs, with standard deviations in parentheses (N=20 in each group).

<table>
<thead>
<tr>
<th>List Repetition</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLI</td>
<td>1.5% (2.5)</td>
<td>3.6% (5.2)</td>
<td>4.1% (7.3)</td>
<td>4.4% (8.0)</td>
</tr>
<tr>
<td>TLD</td>
<td>0.2% (0.9)</td>
<td>0.4% (1.3)</td>
<td>0.9% (1.8)</td>
<td>1.1% (2.0)</td>
</tr>
</tbody>
</table>

Table 3 provides rates of perseverative responses as a function of group and list repetition. A mixed design ANOVA revealed significant main effects of group, $F(1, 38) = 6.54, p = .015$, $\eta^2_p = .147$, SLI: $M = 12.3\%$, TLD: $M = 6.8\%$, and repetition, $F(3, 114) = 14.45, p < .001$, $\eta^2_p = .276$. The group × repetition interaction did not approach significance, $F(3, 114) = 1.01, p = .390$. Children with SLI more often reused responses to earlier cues and/or used of cues as responses. Perseveration occurred more often as the task progressed.

Table 3. Mean percentages of perseverative responses, with standard deviations in parentheses (N=20 in each group).

<table>
<thead>
<tr>
<th>List Repetition</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLI</td>
<td>5.1% (10.3)</td>
<td>11.8% (10.3)</td>
<td>15.4% (10.3)</td>
<td>17.0% (14.1)</td>
</tr>
<tr>
<td>TLD</td>
<td>1.5% (3.0)</td>
<td>8.3% (5.2)</td>
<td>8.5% (6.4)</td>
<td>9.0% (9.4)</td>
</tr>
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</table>

2.2.2 Semantic Relatedness of Responses to Cues

We used two computerized databases (CBOW and LSA) to examine the semantic relatedness of children’s responses to the cues. The CBOW database
computes cosign values that serve as indices of the semantic distance between pairs of words (i.e., with smaller values indicating higher degrees of relatedness between cue and response). Mean cosign values for SLI and TLD groups are shown in Table 4 as a function of list repetition. A mixed design ANOVA revealed a significant main effect of repetition, $F(3, 114) = 43.68, p < .001, \eta^2_p = .535$, and a significant interaction of group $\times$ repetition, $F(3, 114) = 4.46, p = .005, \eta^2_p = .105$. The main effect of group was not significant, $F(1, 38) = 1.26, p = .268$, SLI: $M = .68$, TLD: $M = .67$. These results suggest that children’s responses became more distant to the cues as the task progressed, with greater change in response quality over repetitions in the SLI group.

Table 4. Mean CBOW estimates of semantic distance between cue and response, with standard deviations in parentheses (N=20 in each group).

<table>
<thead>
<tr>
<th>List Repetition</th>
<th>1</th>
<th>2</th>
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</thead>
<tbody>
<tr>
<td>SLI</td>
<td>.63</td>
<td>.68</td>
<td>.71</td>
<td>.72</td>
</tr>
<tr>
<td></td>
<td>(.05)</td>
<td>(.04)</td>
<td>(.05)</td>
<td>(.04)</td>
</tr>
<tr>
<td>TLD</td>
<td>.64</td>
<td>.67</td>
<td>.69</td>
<td>.69</td>
</tr>
<tr>
<td></td>
<td>(.04)</td>
<td>(.03)</td>
<td>(.03)</td>
<td>(.03)</td>
</tr>
</tbody>
</table>

To confirm this pattern of results, we used the LSA database to generate an index of similarity between cue-response pairs. Mean LSA values are provided in Table 5 as a function of group and list repetition. A mixed design ANOVA showed a significant main effect of repetition, $F(3, 114) = 47.18, p < .001, \eta^2_p = .554$, and a significant interaction of group $\times$ repetition, $F(3, 114) = 4.93, p = .003, \eta^2_p = .115$. The main effect of group approached significance, $F(1, 38) = 3.48, p = .070, \eta^2_p = .084$, SLI: $M = .28$, TLD: $M = .30$. These results indicated that children’s responses became less similar to the cues over list repetitions, with a larger decrease in similarity apparent in the SLI group.

Table 5. Mean LSA estimates of similarity, with standard deviations in parentheses (N=20 in each group).

<table>
<thead>
<tr>
<th>List Repetition</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLI</td>
<td>.36</td>
<td>.27</td>
<td>.25</td>
<td>.23</td>
</tr>
<tr>
<td></td>
<td>(.06)</td>
<td>(.05)</td>
<td>(.06)</td>
<td>(.06)</td>
</tr>
<tr>
<td>TLD</td>
<td>.34</td>
<td>.30</td>
<td>.28</td>
<td>.28</td>
</tr>
<tr>
<td></td>
<td>(.05)</td>
<td>(.03)</td>
<td>(.03)</td>
<td>(.04)</td>
</tr>
</tbody>
</table>
2.2.3. Idiosyncratic Responses

Table 6 presents rates of idiosyncratic responses as a function of group and list repetition. A mixed design ANOVA revealed significant main effects of group, $F(1, 38) = 18.42, p < .001, \eta^2_p = .326$, SLI: $M = 49.4\%$, TLD: $M = 36.1\%$, and repetition, $F(3, 114) = 45.69, p < .001, \eta^2_p = .546$, with no interaction, $F(3, 114) = 1.65, p = .182$. Children with SLI produced more idiosyncratic responses than TLD controls; rates increase as the task progressed.

Table 6. Mean percentages of idiosyncratic responses, with standard deviations in parentheses (N=20 in each group).

<table>
<thead>
<tr>
<th>List Repetition</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLI</td>
<td>33.5%</td>
<td>48.9%</td>
<td>54.4%</td>
<td>60.8%</td>
</tr>
<tr>
<td></td>
<td>(10.8)</td>
<td>(14.7)</td>
<td>(16.1)</td>
<td>(17.8)</td>
</tr>
<tr>
<td>TLD</td>
<td>22.2%</td>
<td>35.6%</td>
<td>44.8%</td>
<td>41.8%</td>
</tr>
<tr>
<td></td>
<td>(10.3)</td>
<td>(11.0)</td>
<td>(11.3)</td>
<td>(10.1)</td>
</tr>
</tbody>
</table>

2.3. Discussion

The current study utilized a repeated word association task to assess lexical-semantic organization in 8- to 10-year-olds with SLI and age-matched TLD controls. Consistent with findings of a prior study that tested 6- to 8-year-olds with SLI (Sheng & McGregor, 2010), we observed children with SLI to produce clangs (i.e., responses that were phonologically, but not semantically, related to the cues) at higher rates than children with TLD. Yet, in contrast to Sheng and McGregor (2010), the rates of clangs and other word-finding difficulties were very low, indicating that the majority of children were successful in generating semantically related responses to the cues. Nevertheless, seven of the children with SLI (35\% of the sample) produced clangs and/or exhibited word-finding difficulties on more than 5\% of the trials, in comparison to none of their TLD peers. Children with SLI also showed a greater tendency to perseverate by reusing responses across cues and/or using cues as responses. Higher rates of perseveration in SLI may be a manifestation of executive function deficits (Marton, 2008), or serve as a strategy for overcoming word-finding difficulties.

To evaluate the quality of children’s responses, we computed pairwise indices of the semantic relatedness of responses to cues, using CBOW (Mandera et al., 2017) and LSA (Landauer & Dumais, 1997) databases to obtain estimates of semantic distance and similarity based on very large corpora of English. Although there were no overall differences in semantic relatedness between groups, the responses of children with SLI deteriorated to a greater extent over successive list repetitions, with responses becoming less related to the cues as
the task progressed. Group differences were even more apparent in rates of idiosyncratic responses, which increased dramatically over list repetitions. Children with SLI more often produced responses to cues that were unique, i.e., no other child produced the same response to the cue. Conversely, the TLD group more often produced the same responses to the cues as other children, as illustrated in the following examples with the numbers of children per group indicated: cow $\rightarrow$ moo [8 TLD; 2 SLI], sandwich $\rightarrow$ lettuce [6 TLD; 1 SLI], hand $\rightarrow$ shake [4 TLD; 1 SLI]. Hence, the TLD group showed greater agreement in their responses to the cues.

To explore the ramifications of the lower quality responses that children with SLI produced over list repetitions, we used semantic network models to visualize the responses of each participant group. These models allowed us to explore relationships between the cues that emerged from patterns of shared associations, and whether the resultant structure varied across groups. In modeling the responses, we were interested in instances where different children gave the same responses to different cues. As an example, consider that the following responses occurred in the corpus to both hamburger and sandwich:

- ball, big, bite, bread, cheese, chicken, cow, delicious, eat, good, ham, ketchup, lettuce, meat, mustard, okay, pickle, tasty, tomato, tree, yucky, and yummy. Such overlapping associations suggest perceived similarities between hamburger and sandwich. Our goal was to model the entire corpus of shared associations within each participant group to test whether the resultant network would show a lesser degree of semantic differentiation in children with SLI.

3. Semantic Network Models
3.1. Method
3.1.1. Corpora of Word Associations

For each group (SLI and TLD), we created a corpus comprising children’s responses to 24 cues in the repeated word association task, pooling across participants and list repetitions. To avoid inflating rates of shared associations across cues, we eliminated generic responses coded as word-finding difficulties (anything, nothing, something, or thing) and perseverative responses (i.e., a participant’s reuse of responses across cues or use of cue words as responses).

3.1.2. Modeling Procedure

We used Wolfram Mathematica software version 10.0 (2014) to create semantic network models for the SLI and TLD corpora. These models provided visualizations of globally shared associations, defined as instances where different children gave the same response to different cues. For example, children in the SLI group produced mouse in response to four different cues (i.e., castle $\rightarrow$ mouse; horse $\rightarrow$ mouse; rabbit $\rightarrow$ mouse; dog $\rightarrow$ mouse). Focusing on globally shared associations allowed us to examine the extent to which the responses within each participant group revealed perceived
similarities (semantic relations) between the different cues, resulting in clustering within the semantic network. Note that for the network models reported here, we ignored frequencies of locally shared associations, where varying numbers of children produced the same response to the same cue (e.g., \textit{cow} \rightarrow \textit{moo}), as we had already established that the SLI group had fewer locally shared associations due to greater numbers of idiosyncratic responses.

Modeling was done in two steps. In Step 1, we used the globally shared associations as connections between the cue words to construct semantic networks for SLI and TLD groups, with 24 nodes (i.e., one for each of the cue words) and variable numbers of connections (i.e., dependent on the number of globally shared associations within each group). We then evaluated the small-world properties of the SLI and TLD networks by examining the numbers of connections, global clustering coefficients, and mean distance between nodes. For each network, we compared the observed pattern of connectivity with random networks with the same number of connections (Erdős & Rényi, 1960).

In Step 2, we used the default algorithm (modularity) in Mathematica (Newman, 2004) to extract the “community” structure of the SLI and TLD networks. This allowed us to visualize how the 24 cues congregated into groups (i.e., communities), based on the distribution of globally shared associations. We examined the numbers of communities in each network (SLI and TLD) and whether the networks exhibited weak links between communities (Csermely, 2006), indicating more distinct groups with fewer globally shared associations connecting cues residing in different communities within the network.

### 3.2 Results

#### 3.2.1. Network Connectivity

![Fig 1. SLI network connectivity.](image1)

![Fig 2. TLD network connectivity.](image2)

Figures 1 and 2 depict the semantic networks of the SLI and TLD groups, with globally shared associations creating the differing patterns of connections between the 24 nodes (i.e., cues) in each network. As shown in Table 7, both the SLI and TLD networks exhibited small-world properties, characterized by a
high degree of clustering in the observed shared associations, and short distances
between nodes (cues) in the resultant network. The SLI network had more
connections than the TLD network due to a larger number of globally shared
associations in the SLI corpus. Note that both observed networks had much
higher global clustering coefficients and shorter mean distances between nodes
than the corresponding random networks.

Table 7. Small world properties of SLI and TLD networks in comparison to
random networks.

<table>
<thead>
<tr>
<th></th>
<th>SLI Network</th>
<th>TLD Network</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>(532 connections)</td>
<td>(459 connections)</td>
</tr>
<tr>
<td>Observed Global Clustering</td>
<td>.85</td>
<td>.92</td>
</tr>
<tr>
<td>Observed Mean Distance</td>
<td>1.55</td>
<td>1.08</td>
</tr>
<tr>
<td>Random Global Clustering</td>
<td>.15</td>
<td>.15</td>
</tr>
<tr>
<td>Random Mean Distance</td>
<td>2.23</td>
<td>2.39</td>
</tr>
</tbody>
</table>

3.2.2. Network Community Structure

Figures 3 and 4 show the community structure for SLI and TLD networks
that resulted from application of the modularity algorithm in Mathematica
(Newman, 2004) to the corpus of globally shared associations. Each corpus
yielded three communities (i.e., groups of cues) with different members and
patterns of connectivity. For instance, the cue clown was in a community with
eight other cues (cake, cow, dog, horse, pen, rabbit, hamburger, and sandwich)
in the SLI network, but in a community with only five other cues (balloon, cake,
dog, hamburger, and sandwich) in the TLD network. Notice that in the SLI
network, the greater number of globally shared associations between cues
residing in different communities resulted in less differentiated communities. To
illustrate, consider that four children with SLI gave the response bad to four different cues: balloon, clown, hair, and hammer, in comparison to one child with TLD who said bad in response to shark; likewise, three children with SLI gave the response smile to three different cues: hamburger, clown, and shirt, in comparison to two children with TLD who said smile in response to clown. These and other globally shared associations in the SLI network connected clown with cues in other communities, such as balloon, hair, hammer, and shirt. In contrast, in the TLD network, the smaller number of globally shared associations connecting cues in different communities resulted in weak links, effectively separating the three communities from each other.

3.3. Discussion

Semantic network models provided a tool for visualizing emergent patterns in the responses of children with SLI versus TLD to the 24 cues used in the repeated word association task. Our goal was to shed light on how the children perceived similarities between the cues, and how the lexical-semantic organization of the cues in the resultant semantic networks might differ for children with SLI in comparison to their TLD peers. As input to the models, we used globally shared associations (i.e., the same response made to different cues by different children in a participant group) rather than locally shared associations (i.e., the same response made to the same cue by different children in a participant group). Note that the latter response type had already been determined to be less frequent in children with SLI, who produced more idiosyncratic responses (i.e., responses to a given cue that no other child made). Although the SLI network had more connections than the TLD network, due to greater numbers of globally shared associations, both networks showed small-world structure, with high global clustering coefficients and short mean distances between nodes, relative to random networks with the same number of connections. Next, we applied the default modularity algorithm to generate the community structure of each semantic network. Although the 24 cues congregated into three communities in both the SLI and TLD networks, only the TLD network exhibited weak-link structure due to a paucity of globally shared associations between cues residing in different communities. Less differentiated lexical-semantic structure would be expected to contribute to inefficiencies in lexical access, as is observed in children with SLI (Hennessey et al., 2010; Mainela-Arnold & Evans, 2005).

4. General Discussion

Accessing words that are semantically relevant to the discourse context is a critical aspect of language processing. Over four decades of research using priming paradigms has demonstrated the facilitative effects of semantically related cues on lexical access (e.g., Meyer & Schvaneveldt, 1971; Neely, 1977). Priming studies involving children with SLI indicate that these children often
fail to benefit from semantic cues in spoken-word production and recognition tasks (Brooks et al., 2014; Velez & Schwartz, 2010). Such findings complement other work suggesting lexical-semantic deficits in SLI, such as difficulties in fast mapping words onto concepts (Rice et al., 1990) and generating word definitions (Marinellie & Johnson, 2002).

The current study used a repeated word association task to explore lexical-semantic organization in SLI. 35% of the children with SLI (and none of the TLD controls) exhibited word-finding difficulties and/or produced clangs (phonologically related responses) on greater than 5% of trials. Children with SLI also produced more perseverative responses, consistent with reports of high rates of perseveration in SLI in verbal fluency tasks (Dunn, Gomes, & Sebastian, 1996), and more idiosyncratic responses. To estimate the semantic relatedness of children’s responses to the cues, we used the CBOW and LSA databases to obtain indices of semantic distance and similarity. Surprisingly, we did not observe children with SLI to produce responses that were more semantically distant or less similar to the cues overall. However, they showed greater deterioration in the quality of their responses over list repetitions.

Next, we constructed semantic network models for each participant group to explore perceived semantic relationships among the cues, using globally shared associations (i.e., the same response made to different cues) as input to the models. Our approach was inspired by word association studies that pool responses of multiple participants to cues to create a corpus (Hills, Maouene, Maouene, Sheya, & Smith, 2009; Nelson, McEvoy, & Schrieber, 2003). Both SLI and TLD networks showed small-world properties, with high clustering coefficients indicating similarities among the cues and short distances between nodes allowing for fast search and retrieval (Borge-Holthoefer, & Arenas, 2010). Differences in network structure were apparent in the greater number of connections in the SLI network and lesser differentiation in their distribution. Only the TLD network exhibited weak links between groups of cues, due to fewer associations connecting cues residing in different parts of the network. Networks with more distinct communities may be more efficient for lexical search, by allowing users to search for relevant information in a circumscribed part of the network (Csermely, 2006). Our results extend findings of Beckage, Smith, & Hills (2011), who, using vocabulary estimates from the MacArthur-Bates CDI as input to semantic network models, found less clustering in the networks of late-talking toddlers in comparison to age-matched controls and a greater number of idiosyncratic ‘oddball’ words in late-talkers’ vocabularies. Similarly, we observed the SLI network to exhibit somewhat a lower clustering coefficient and higher mean distance between nodes than the TLD network, and found children with SLI to show heightened use of idiosyncratic responses. Future research should pursue the hypothesis that differences in semantic network structure contribute to the word-finding difficulties, semantic errors, and failures to benefit from semantic context that are observed in children with SLI, thereby, operationalizing the construct of fragile, underspecified lexical representations in SLI (McGregor, Friedman, et al., 2002).
References


