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# Sentence processing strategies in children with expressive and expressive–receptive specific language impairments

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## Abstract

The purpose of this study was to investigate the sentence comprehension strategies used by children with expressive and expressive–receptive specific language impairments (SLI) within a language processing framework. Fourteen children with SLI (ages 6;10–7;11) meeting strict selection criteria were compared to seven age-matched and seven younger normal controls. Children were asked to determine the agent in sentences composed of two nouns and a verb (NVN, NNV, VNN) with animacy of the noun as a second factor. Results of group comparisons revealed that children with E-SLI and ER-SLI differed from each other in the comprehension strategies they employed as well as differing from both age-matched and younger normal language control groups. Children with E-SLI relied exclusively on a first noun as agent strategy across all conditions, whereas children with ER-SLI used animacy cues when available. Additionally, maximum likelihood estimates were calculated to investigate individual patterns of performance under different cue conditions. Results revealed a significant correlation between severity of receptive language abilities and the type of strategy used, with better receptive language skills being highly correlated with children's use of word order cues.

*Keywords*: language disorders, language processing, SLI subgroups, comprehension.

## Introduction

The term *specific language impairments* (SLI) refers to a group of children who demonstrate language disorders in the absence of any clearly identifiable aetiology. Traditionally, these children have been treated as a single population defined on the basis of exclusionary criteria (e.g. normal non-verbal intelligence, normal hearing,

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and no visible sign of neurological or emotional impairments; Stark and Tallal 1981). It appears, however, that SLI is not an homogeneous group. In particular, research suggests that children with both expressive and receptive deficits (ER-SLI) can be contrasted to those having only expressive deficits (E-SLI).

Findings from studies employing status assessment measures (e.g. Aram and Nation 1975, Wolfus *et al.* 1980, Stark and Tallal 1988) indicate that children with E-SLI demonstrate good receptive vocabulary, syntax comprehension, normal memory span, and good phonological discrimination, but have deficits in expressive semantics and syntax as well as formulation difficulties in rapid motor sequencing. In contrast, children with ER-SLI exhibit deficits in receptive vocabulary, syntax comprehension, phonological discrimination and decreased memory span in conjunction with deficits in expressive syntax and semantics. However, production of consonant clusters, diphthongs, and multisyllabic words is significantly better for ER-SLI than for E-SLI children.

Experimental studies also reflect subgroup differences. At the lexical level, children with poor receptive and expressive language abilities are slower and less efficient in word-finding, picture naming, and auditory rehearsal skills (Leonard *et al.* 1983, Kail and Leonard 1986, Gathercole and Baddeley 1990). At the discourse level, these children's conversational responses are slower and less efficient than children with good receptive language abilities (e.g. Craig and Evans 1989, 1993). In contrast, in spontaneous speech, SLI children with good receptive language abilities make more grammatical errors, and omit more function words in utterances that have greater verbal and non-verbal processing demands, compared to children with poor receptive and expressive skills (Evans 1996, Evans *et al.* 1997).

Studies of the comprehension strategies used by children with SLI also demonstrate subgroup differences that seem to vary with the severity of the children's receptive language deficits. In particular, children with *good* receptive skills appear to use more word order strategies, whereas children with *poor* receptive language abilities rely more on semantically based strategies. For example, on standardized assessment measures (e.g. Test of Receptive Grammar (TROG); Bishop 1979), SLI children with receptive deficits had difficulty using word order cues to interpret sentences. In sentence processing tasks designed to investigate children's use of word order versus semantic strategies, children with poor receptive and expressive skills (e.g. ER-SLI) exhibited chance levels of performance for sentences when only word order cues were made available (van der Lely and Dewart 1986, van der Lely and Harris 1990).

In contrast, in studies of children with good receptive language skills (e.g. E-SLI), it can be seen that these children seem to be able to use word order cues in sentence comprehension tasks (Bishop 1982, Adams 1990). For example, Adams (1990) found that children with good receptive language skills were able to use word order cues to correctly comprehend reversible active and double object sentences; constructions requiring the use of word order cues. Further analysis of these children's errors patterns for embedded clauses, embedded phrases, and passives also revealed their use of word order based strategies. Thus, it appears that SLI children's ability to use word order cues to comprehend sentences may vary with severity of receptive language deficits. However, this subgroup question has yet to be addressed directly.

Recently, several processing based models have been proposed as possible accounts of specific language impairments (e.g. Bishop 1992, Johnston 1995, Leonard 1995). However, these accounts focus primarily on the expressive language deficits characteristic of this population. Although there is reason to suspect a relationship between processing deficits and expressive language impairments, little research has focused on comprehension deficits in this group from a processing based framework. The model employed in this study to investigate a performance based account of sentence comprehension in children with SLI was the competition model developed by Bates, MacWhinney and their colleagues (Bates *et al.* 1984, Bates and MacWhinney 1987, 1989).

During sentence comprehension the child is required to attend simultaneously to multiple transient and fleeting acoustic, phonetic, semantic, morphological, syntactic and intonational cues. The Competition Model provides an account of language comprehension which focuses on this process of converting multiple competing cues into a linear speech stream. Three key concepts—cue validity, cue strength, and cue cost—are included in the model to capture the multidimensional nature of language comprehension. Within this theoretical framework, *cue validity* is defined as the information value of a given lexical or grammatical feature. Operationally, it is the product of a cue's *availability* and *reliability*. Or more simply put, cue validity is the proportion of the time a cue is present and indicates the correct interpretation (i.e. role assignment) in a given language.

*Cue strength*, in contrast, is a measure of the strength to which a given individual has approximated the validity of a given cue in his or her language. During language acquisition, the process of determining the roles of nouns as actor or patient is a difficult task. The mappings between cues that mark these roles and the roles themselves are many-to-many. For example, the cue for noun animacy tends to mark the role of actor in many cases (e.g. 'the boy hit the ball'). Yet the animacy cue is not always present (e.g. 'the bat hit the ball'), or correct in marking the role of actor (e.g. 'the ball hit the boy'). Thus, according to the competition model, the strength of a cue for an individual speaker is proportional to its informational value or cue *validity*.

Individual limitations in processing capacity during real-time language use will affect cue strengths for individual speakers. The third theoretical concept, *cue cost*, is a general measure of the processing costs associated with the real-time use of a given cue (e.g. memory, speed of processing limitation, fatigue). The Competition Model holds that the processing costs of different linguistic 'cues' will differ across individual speakers, reflecting the individual's information processing abilities.

Cue cost and cue validity affect not only the degree to which children will believe or 'trust' certain cues, but also the developmental order with which children come to rely on different cues. For example, children will pick up cues in order of their validity with the first cues learned by the child being the most reliable ones in his or her language. However, if a given cue has high cue validity but also high processing cost, there will be a delay in the child's use of the cue. Studies of typically developing children reveal that, in the early stages of language development (i.e. 2 years of age), children rely primarily on animacy cues to interpret sentences, yet by 4 years of age, English speaking children begin to rely more on word order cues to process canonical word order (SVO), but continue to rely on animacy cues for non-canonical word orders (OSV, and VOS). By 7 to 12 years of age, however, children are able to use word order cues to process non-canonical (OSV and VOS) forms as well (Bever 1970, Nelson 1974, Bates *et al.* 1984, von Berger *et al.* 1993).

Many of the important predictions of the Competition Model are based on the processing of sentences in which multiple linguistic cues are in agreement or in competition. The Competition Model predicts that the *cost* associated with the real-time processing of multiple cues will differ depending on the patterns of co-occurrence of these cues. For example, in English sentences with the first noun animate and the second inanimate (e.g. NVN-AI) both word order and animacy cues *support* the interpretation of first noun as agent. However, for NVN sentences where the first noun is inanimate and the second is animate (e.g. NVN-IA), word order and animacy cues are in *conflict*, with word order cueing the first noun for the role of agent, but animacy cueing the second noun. The use of word order cues during language comprehension requires the child to process and temporarily store, in serial order, both immediate and final interpretations of multiple competing meanings. The competition model predicts that, if processing costs exceed available resources, children with SLI may rely instead on comprehension strategies (e.g. whole world semantic knowledge) which have high cue validity but lower cue costs.

Detailed examination of SLI children's responses in competing and co-occurring cue conditions provides a framework to investigate possible subgroup differences in the use of word order versus animacy sentence processing strategies. The goal of this study, therefore, was to employ a processing based model of comprehension to investigate the sentence processing strategies of children with SLI differing in receptive language abilities. Two specific questions were posed:

(1) Do the sentence processing strategies used by children with SLI vary with the severity of receptive language deficits?
(2) With changes in cue conflict levels, do the sentence comprehension strategies change for children with E-SLI and ER-SLI?

## Method

### *Participants*

The subjects for this investigation were 28 children: 14 with SLI (ages 6;9–7;11), seven chronologically age-matched controls (ages 6;10–7;9) and seven younger normal language controls (ages 4;0–4;2). The children with SLI were selected to meet the following criteria:

(1) non-verbal IQ greater than 85 based upon either the Weschler Intelligence Scale for Children-Revised (WISC-R) (Wechsler 1974), or the Columbia Scale of Mental Maturity (CMMS) (Burgemeister *et al.* 1972);
(2) speech intelligibility greater than 95% as measured by the Arizona Articulation Performance Scale (AAPS) (Fudala and Reynolds 1986);
(3) hearing within normal limits;
(4) no significant emotional or frank neurological impairments.

Children were further selected for this study to comprise two distinct groups differing in receptive language abilities (table 1), based upon the composite receptive and expressive language scores from the *Clinical Evaluation of Language Functions—Revised* (CELF-R; Semel *et al.* 1987). The CELF Expressive Language Score comprises three subtests:

(1) word classes (WS);
(2) formulating sentences (FS); and
(3) recalling sentences (RS).

**Table 1. Means and standard deviations for age, and the expressive and receptive language scores for the CELF-R (SS) for expressive (E-SLI) and expressive–receptive (ER-SLI) subjects**

| | Age | CELF-R | |
|---|---|---|---|
| | | (RLS) | (ELS) |
| | Mean (SD) | Mean (SD) | Mean (SD) |
| E-SLI | 7;6 (3.6) | 89 (6.5) | 65 (2.9) |
| ER-SLI | 7;3 (3.8) | 70 (6.7) | 50 (1.0) |
| CA | 7;4 (3.5) | NA | NA |

The CELF Receptive Language Score comprises three subtests:

(1) linguistic concepts (LC);
(2) sentence structure (SS); and
(3) oral directions (OD).

In keeping with prior subgroup classification criteria (Evans 1996, Evans *et al.* 1997), children were designated as E-SLI if their composite receptive language scores were less than 1 SD from the mean ($x=89$; SD 6.7), but their expressive language scores were more than 2 SD below the mean ($x=65$; SD 2.9). Children were designated as ER-SLI if their composite receptive language scores were more than 1.5 SD below the mean ($x=70$; SD 6.5), and their expressive language scores were more than 2 SD below the mean as well ($x=50$; SD 1.0).

### *Task*

Fifty-four grammatical and semi-grammatical sentences comprised of two nouns and a verb with animacy as a second factor were presented to the children. The sentences were of the form NVN, NNV, and VNN, consistent with previous research with the Competition Model (e.g. Bates *et al.* 1984). Nouns were either animate/animate (AA), animate/inanimate (AI), or inanimate/animate (IA). The same enactment paradigm used in previous research with school-aged children within the Competition Model (Wulfeck 1993) was used in this study. Children were presented pictures of two nouns and asked to point to the one that was 'doing' the action.

To prevent possible interference of role assignment due to intonational cues, all sentences were presented with the same intonational contour pattern appropriate for well-formed sentences. Speech stimuli were digitized using SoundEditPro, and stored in 16 bit, 22 Hz format on a Macintosh Quadra 660AV. The sentence stimuli, the position of the correct answer, and the order of presentation were generated randomly using PsyScope (Cohen *et al.* 1993). Examples of grammatical and semi-grammatical forms as well as the nouns and verbs used to construct the sentences are shown in the Appendix.

Each child was tested individually in a quiet room. Prior to the experimental task, each child was presented 10 training items which were similar but not identical to the test sentences. Children were instructed to listen carefully since they would hear each sentence only once. All of the children were able to complete the training items. After the training items were completed, the children again were reminded to choose the animal or object they thought was doing the action and to listen carefully, as they would hear each sentence only once.

## Results

The first question was, how do the two SLI groups differ from each other and their age-matched peers with respect to sentence comprehension strategies? A 3×3×3 mixed-model analysis of analysis of variance (ANOVA) was conducted with percentage choice of the first noun as the dependent variable. The two within-subject factors were word order (NVN, NNV, VNN) and animacy (AA, AI, IA) and the between-subjects factor was group (E-SLI, ER-SLI, CA). The results revealed significant main effects for word order ($F(2,36)=16.15$, $p<0.001$), animacy ($F(2,36)=23.2$, $p<0.001$) and group ($F(2,18)=27.6$, $p<0.001$). There also was a significant group-by-animacy interaction effect ($F(4,36)=4.43$, $p<0.01$). *Post hoc* analysis revealed that the E-SLI and CA groups did not differ significantly from each other, but that the ER-SLI group differed significantly from both the E-SLI and CA groups.

The results can be understood more clearly by looking at figures 1–4, which illustrate the group differences in sentence comprehension strategies. The percentage first noun choice for the three word order conditions for the E-SLI, ER-SLI, and CA groups is shown in figure 1. The first noun was the predominant choice for all three word order conditions for the children with E-SLI. For the CA group, a slight shift in the pattern of noun choice can be seen between the NVN and the other two conditions. In the NVN condition, first noun choice was high for the CA group. However, in the NNV and VNN conditions, the CA group shifted to a

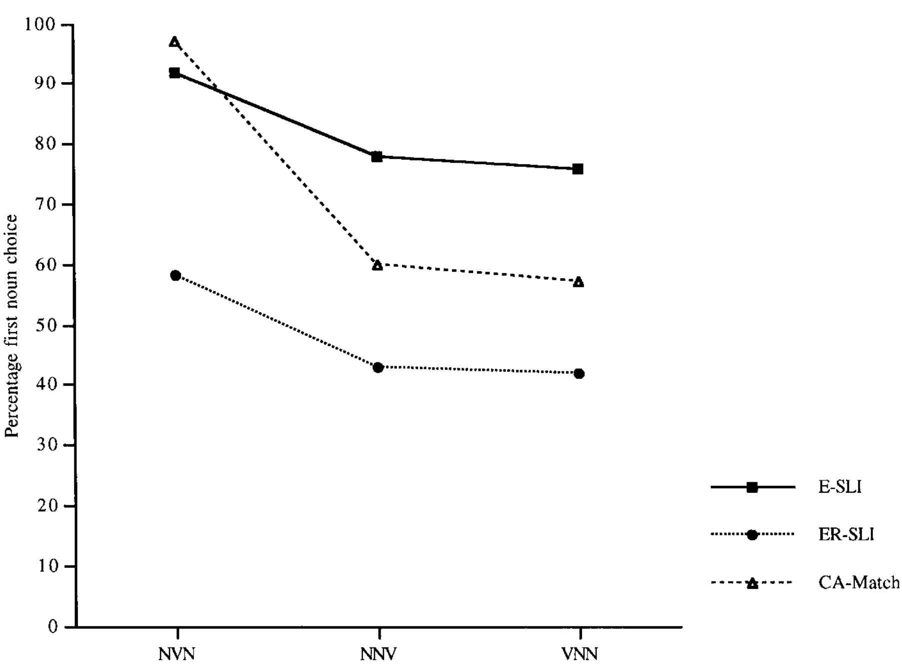


Figure 1. Word order effects for E-SLI, ER-SLI and CA-matched controls.

second noun choice strategy; a pattern consistent with an OSV strategy previously reported for children this age and adults (MacWhinney *et al.* 1985, von Berger *et al.* 1993). For the ER-SLI group, however, the percentage first noun choice was at or slightly above chance across levels for all three word order conditions (40–58%).

These group differences can be seen more clearly across the three animacy conditions shown in figure 2. The percentage first noun choice for the E-SLI group was high across all three animacy conditions, and did not differ statistically, nor did the E-SLI group differ from the CA group across the three conditions. The percentage first noun choice was significantly different across the three conditions for the ER-SLI group, however. For the AA condition in which both nouns were animate (e.g. the condition where animacy is effectively removed as a cue), the percentage first noun choice for the ER-SLI group was at chance levels. For the AI condition, in which only the first noun was animate, the percentage of first noun choice for the ER-SLI was high (79%) and for the IA condition, in which the second noun was animate, percentage first noun choice was low (19%), indicating that these children with receptive deficits were relying not on word order but on animacy cues instead.

The differences between the two subgroups are the clearest in the NVN word order condition shown in figure 3. For both the E-SLI and CA groups, the choice of first noun was high across all three animacy conditions. For the ER-SLI children, choice of first noun was slightly above chance levels in the condition where both nouns were animate (AA: 64%); high when the first noun was animate (AI: 90%); and extremely low when the first noun was inanimate (IA: 21%), indicating that the children with good receptive language abilities were using word order to process

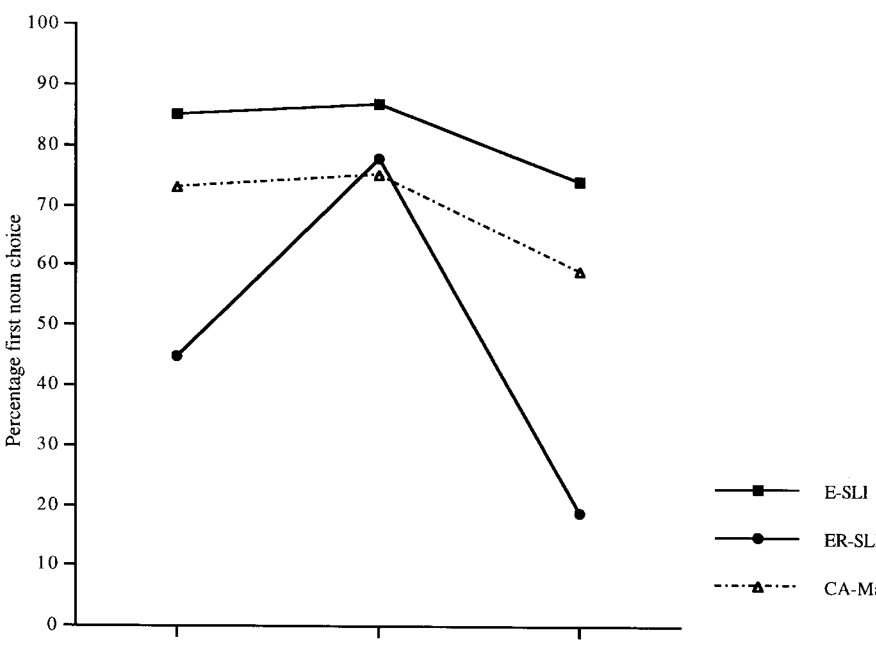


Figure 2. Animacy effects for E-SLI, ER-SLI and CA-matched controls.

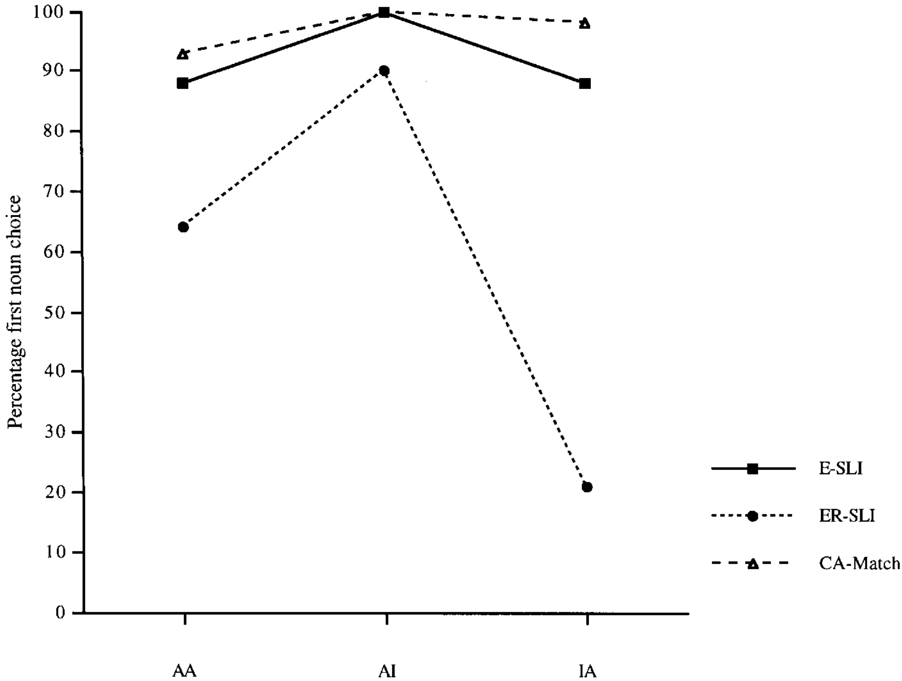


Figure 3. Animacy effects for NVN word order.

sentences, whereas the children with poor receptive language abilities were relying exclusively on animacy cues.

Three different patterns of cue competition, contrasting a low, high and null cue conflict contexts are presented in figure 4. The NVN-AI condition represents a low cue conflict condition due to the convergence of the animacy and word order cues which both support first noun as agent. The NVN-IA pattern represents a high cue conflict condition with animacy cueing the last noun as agent and word order cueing the first noun. The VNN-AA pattern represents a null cue condition where there are no cues for either word order or animacy.

One might argue that little can be learned from the use of ungrammatical sentences, as in the VNN-AA condition. However, patterns of responses to these ungrammatical sentences can provide valuable insights into the strategies employed by children with language disorders when confronted with unfamiliar or *novel* sentence forms. MacWhinney *et al.* (1985) have shown that the processing of ungrammatical sentences provides an accurate measure of cue strength in grammatical sentences. This can be seen clearly in the different processing strategies used by the two language-impaired groups and the normal 7;0 year old peers across the three cue conflict conditions. In the NVN-AI, the percentage first noun choice was high for all three groups (E-SLI, 100%; ER-SLI, 91%; CA, 100%). In the NVN-IA, however, the performance of the E-SLI and the CA groups differed distinctly from the ER-SLI group. For the E-SLI and CA groups, first noun choice was still high despite the competing animacy cues. For the ER-SLI children, however, first noun choice was extremely low (21%), indicating a strong second 'animate noun' choice instead.

In the VNN-AA condition, the pattern of performance for the three groups

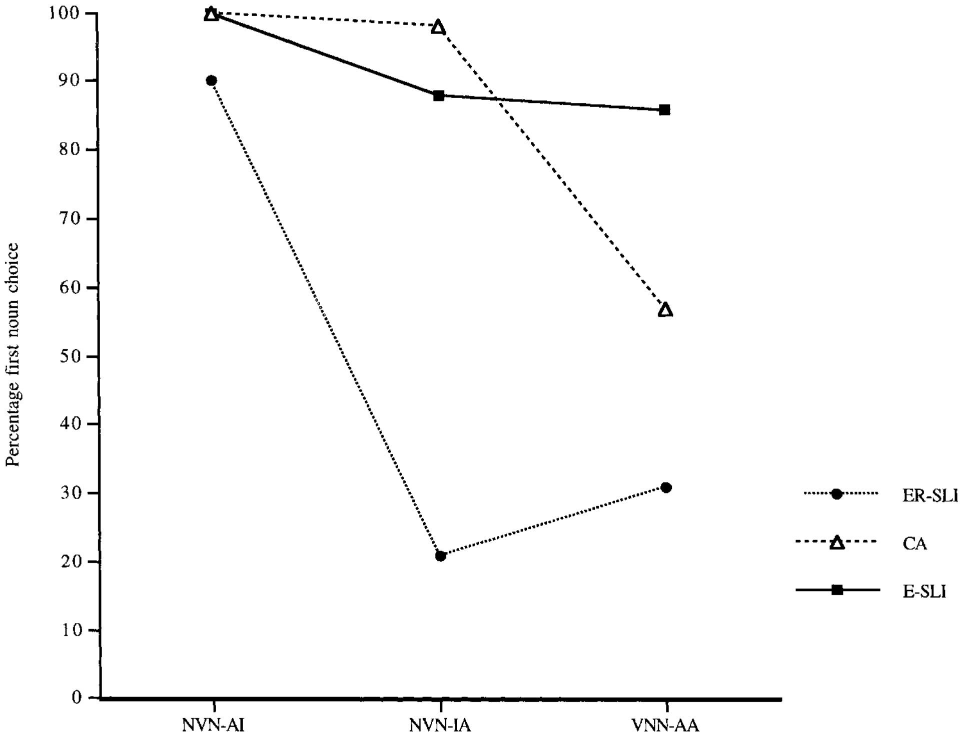


Figure 4. Percentage first noun choice across high, low and null cue conflict conditions for E-SLI, ER-SLI and CA-matched groups.

differed in interesting ways. For the E-SLI children, choice of first noun was still high, but for the CA-group, choice of first noun dropped to chance levels (58%), suggesting that for typical 7;0 year old children, the absence of any word order or animacy cues profoundly disrupted their performance and resulted in guessing. In contrast, the ER-SLI group's choice of first noun was still low. In the absence of animacy cues, however, responses in this context suggest that these children were choosing the *last* word they heard, indicating a possible recency effect. Thus, the children with good receptive abilities appeared to use a strict 'first noun' strategy across cue conditions, seemingly unaware of the absence of word order or animacy cues in the VNN-AA condition. In contrast, the children with poor receptive language abilities consistently relied on animacy cues when these cues were made available, but appeared unable to hold the order of words in memory when animacy cues were not available, choosing the last noun in these contexts.

Given the ER-SLI group's reliance on animacy cues, we might ask whether their processing strategies are characteristic of younger normally developing children. The ER-SLI children's expressive skills, as measured by standardized expressive language measures, were comparable to those of 3 year olds, whereas their receptive language scores were comparable to those of 4 year olds; thus data from 4 year old normal language controls was collected instead. A $3 \times 3 \times 2$ mixed-model analysis of variance comparing the percentage first noun choice for ER-SLI and the younger 4 year normal language control group was conducted, with the same two within-subject factors (word order and animacy) and the between-subject factor being group (ER-SLI, 4;0). Results revealed a significant main effect for word order ($F(2,24) = 14.1$, $p < 0.0001$), animacy ($F(2,24) = 17.4$, $p < 0.0001$) and group ($F(1,12) = 5.89$, $p < 0.01$), as well as a significant group-by-animacy interaction effect ($F(4,48) = 9.44$, $p < 0.001$). The pattern of performance for the ER-SLI and 4 year old children is displayed in figure 5. The percentage first noun choice for the ER-SLI group was high in the AI condition and low in the IA condition. In contrast, the percentage first noun choice for the 4;0 control group was high across animacy conditions, similar to the performance of both the E-SLI and CA-matched groups examined earlier. This suggests that children with ER-SLI are not simply delayed in the comprehension strategies they use; instead, the processing strategies they use are qualitatively different from those of younger typically developing children as well.

The results of the analysis of variance revealed that differences in the sentence comprehension strategies for the two groups of children with SLI not only differed from each other but from normally developing control groups as well. However, this statistical approach does not provide information regarding the direction and relative strength of the word order or animacy cues for the two SLI groups nor does it allow for analysis of individual patterns of performance. Maximum likelihood estimation (MLE) techniques, in contrast, have been used successfully to investigate individual differences in children with SLI in general (Evans *et al.* 1997) and in particular with this specific task paradigm (McDonald and MacWhinney 1989, Evans and MacWhinney 1995, 1996). MLE uses an iterative procedure in

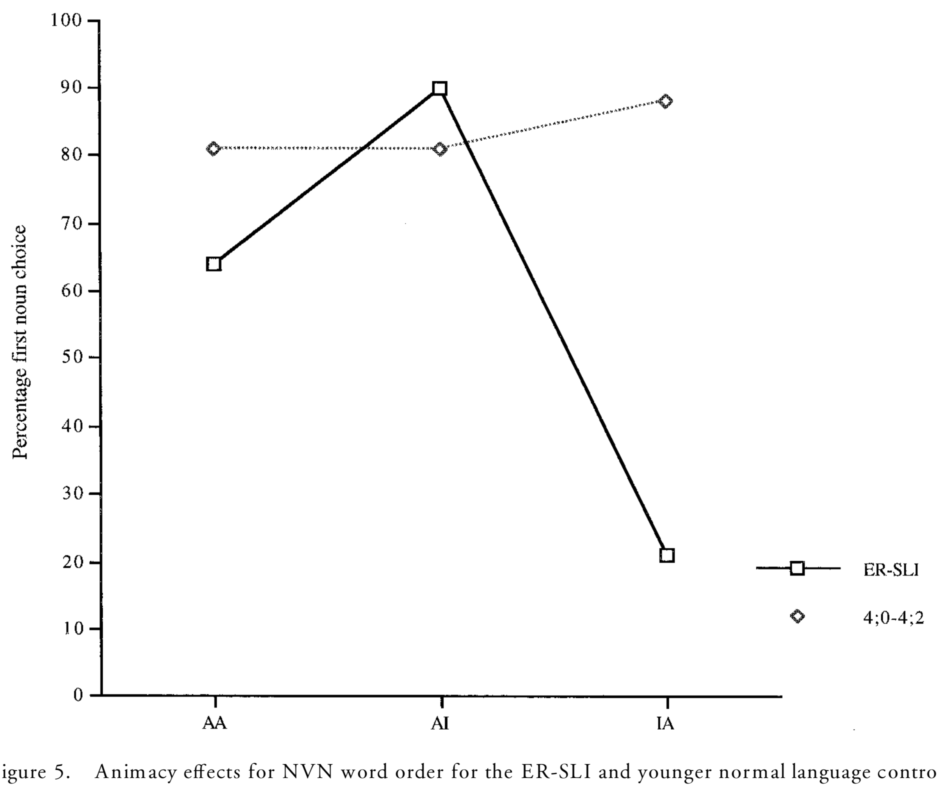


Figure 5. Animacy effects for NVN word order for the ER-SLI and younger normal language control groups.

conjunction with a mathematical model to find values for parameters in a model which best fit the data, thereby providing direct estimations of the relative strength of cue usage for both groups and individuals. The specific model used for this study (McDonald and MacWhinney 1989) predicts the probability of choosing the first noun as actor based on the strengths of word order and animacy cues. The model is presented below, where:

$$P \text{ (first noun choice)} = \frac{\Pi_i S_{i1}}{\Sigma_j (\Pi_i S_{ij})}$$

where $S_{i1}$ is the strength with which cue $i$ favours a noun candidate, $i=1$ to $I$, where $I$ is the total number of cues available, and $j=1$ to $J$, where $J$ is the total number of candidates for actor, in this case 2.

In this study, the children had to pick one of the two nouns as the actor of the sentence. It was assumed that the degree to which either word order or animacy resulted in the child's favouring one noun as the actor was an additive complement to the degree to which the child favours the other noun. In the case of animacy for example, if the child preferred the first noun in an AI sentence at some given strength $S$ then the complementary strength of the child's favouring the second noun was $(1-S)$.

Separate parameters were estimated for each level of each cue, with three levels of animacy (AA, AI, IA) and three levels of word order (NVN, NNV, VNN). Using the same procedure outlined by McDonald and MacWhinney (1989), parameters were estimated using the STEPIT program of Chandler (1969). An iterative process was used to obtain a fit that minimized the squared deviations between the observed data points and those predicted by the model. STEPIT also provides goodness-of-fit statistics, including the root mean squared deviation (RMSD) and the correlation ($r^2$) between the model's predictions and the data. When the procedure is allowed to set its own parameter weights, the statistics are a measure of how well the model fits the data. A high correlation between the model and the data indicates that it has captured the ordering of the cue strengths.

The results from the ANOVAs revealed that word order was a strong cue for the E-SLI, CA, and 4;0 year old groups and that animacy was a strong cue for the ER-SLI group, but these analyses revealed little about the relative strength of these cues for the four groups. The parameter estimates for the two language disordered and the two normal language control groups are presented in table 2. The parameter estimates clearly show the strong first noun preference for the E-SLI group (estimates substantially above 0.5 for NVN, NNV, and VNN conditions). The parameter estimates for the CA and 4;0 groups correspond to the developmental trends

**Table 2. Parameter estimates for the three word order conditions (NVN, NNV, VNN) and the three animacy conditions (AA, AI, IA) for the expressive SLI, chronologically age matched (CA), younger normal (4;0–4;2) and expressive/receptive SLI groups**

| | NVN | NNV | VNN | AA | AI | IA | RMSD | $r^2$ |
|---|---|---|---|---|---|---|---|---|
| E-SLI | 0.93 | 0.79 | 0.72 | 0.62 | 0.53 | 0.38 | 0.02 | 0.95 |
| CA | 0.98 | 0.59 | 0.55 | 0.55 | 0.67 | 0.32 | 0.03 | 0.97 |
| 4;0–4;2 | 0.85 | 0.55 | 0.40 | 0.43 | 0.59 | 0.43 | 0.05 | 0.92 |
| ER-SLI | 0.62 | 0.41 | 0.38 | 0.47 | 0.80 | 0.18 | 0.04 | 0.96 |

reported in previous studies (MacDonald and MacWhinney 1989), with a strong preference for first noun in the NVN word order, no real preference in the NNV, and VNN word orders and no preference across any of the animacy conditions. In contrast, the parameter estimates for ER-SLI children were high in the AI cue condition and extremely low in the IA cue condition (i.e. low percentage first noun choice), indicating a strong preference for animacy and no preference for any word order conditions (estimates 0.30–0.50). The low RMSD values and the high $r^2$ values indicate a good fit between the model and the data, as well as the ordering of these cue strengths for all of the groups.

The real advantage of the MLE technique, however, is its ability to model *individual* differences in performance. The parameter estimates for each SLI child are presented in table 3 for the NVN and AI cues. Inspection of the individual cue preferences reveals some interesting patterns. For the majority of the E-SLI children, word order alone, again, clearly was the cue being used to assign the actor in a sentence. For the majority of the ER-SLI children, the use of animacy was clearly the predominant strategy instead.

Spearman rank order correlation coefficients revealed that the correlations between the parameter estimates for the word order cue and several of the subtests of receptive language abilities from the CELF-R were significant. The correlation of the level of word order cues with the subtests assessing memory for directions (Oral Directions), memory for spoken language (Recalling Sentences) and knowledge of morphology (Word Structure) were significant (OD, $rs = 0.73$, $p < 0.03$; RS, $rs = 0.79$, $p < 0.01$; WS, $rs = 0.81$, $p < 0.01$), but not for expressive language abilities (MLU), or knowledge of grammatical structures (SS).

Closer inspection of parameter estimates for subjects E-SLI 7, and ER-SLI 1, 3 and 7 also indicate individual differences as well. The percentage first noun choice

**Table 3. Parameter estimates for word order (NVN) and animacy (AI) conditions, standardized scores for receptive language subtests of the CELF-R (oral directions, word structure, sentence structure, recalling sentences), and mean length of utterance (MLU) for children with expressive and expressive/receptive SLI**

| | NVN | AI | OD† | WS† | SS† | RS† | MLU |
|---|---|---|---|---|---|---|---|
| E-SLI | | | | | | | |
| 1 | 0.99 | 0.62 | 9 | 6 | 14 | 6 | 3.0 |
| 2 | 0.88 | 0.58 | 9 | 5 | 9 | 6 | 4.68 |
| 3 | 0.86 | 0.64 | 5 | 5 | 9 | 6 | 5.38 |
| 4 | 0.99 | 0.66 | 9 | 5 | 9 | 4 | 4.4 |
| 5 | 0.99 | 0.70 | 8 | 5 | 7 | 4 | 4.13 |
| 6 | 0.99 | 0.65 | 10 | 5 | 6 | 5 | 3.68 |
| 7 | 0.97 | 0.95 | 9 | 5 | 6 | 5 | 4.70 |
| ER-SLI | | | | | | | |
| 1 | 0.86 | 0.71 | 7 | 3 | 6 | 3 | 2.47 |
| 2 | 0.62 | 0.97 | 4 | 4 | 9 | 3 | 3.07 |
| 3 | 0.85 | 0.87 | 6 | 3 | 6 | 3 | 3.34 |
| 4 | 0.67 | 0.99 | 5 | 4 | 6 | 3 | 3.86 |
| 5 | 0.68 | 0.99 | 5 | 3 | 5 | 3 | 2.7 |
| 6 | 0.22 | 0.77 | 4 | 3 | 4 | 3 | 2.58 |
| 7 | 0.50 | 0.48 | 4 | 3 | 5 | 3 | 2.79 |

†Oral directions, word structure, sentence structure, recalling sentences.

for the three animacy and word order conditions are presented in table 4 for these children. In cases where animacy was not available as a cue (e.g. AA), subject E-SLI 7 relied on word order and chose the first noun as the agent (NVN 67%, NNV 100%, VNN 100%). However, when animacy cue was available (e.g. AI, IA), this child chose the animate noun. Thus, in conditions where no cues were available, E-SLI 7 used a first noun choice strategy, but when word order and animacy cues were combined, this appeared to confuse this child, causing him to revert back to an animacy strategy.

Interestingly, for the two children in the ER-SLI group with the highest scores on the Oral Directions subtest of the CELF-R (ER-SLI 1 and 3), it appeared that in familiar word order conditions (NVN), these children were able to use word order cues, choosing the first noun, but in less typical (NNV) or unfamiliar (VNN) word order conditions, these children reverted to the use of animacy. Finally, the parameter estimates for the child with the most severe expressive and receptive deficits (ER-SLI 7) indicate the absence of any consistent sentence comprehension strategy, suggesting that this child was possibly guessing.

## Discussion

The two questions posed in this study were: (1) Do the processing strategies employed by children with SLI vary with the severity of receptive language deficits? and (2) With changes in cue conflict levels, do subgroups of children with SLI differ in their comprehension strategies? With regard to the first question, this study shows that children with better receptive language abilities used word order as the predominant comprehension strategy, whereas children with more severe receptive deficits relied on animacy cues instead. This finding is consistent with prior research indicating that children with more severe receptive deficits rely heavily on semantic cues during sentence comprehension tasks (van der Lely and Dewart 1986, van der Lely and Harris 1990).

The E-SLI and ER-SLI groups in this study differed not only in the degree of receptive deficits, but in expressive deficits as well. One might argue that the observed differences could be the result of overall severity, not differences in receptive abilities alone. The correlations between the child's use of word order cues and the *receptive* language subtests were significant, but were not significant for the *expressive* measures. Analysis of individual differences did reveal, however, that the two children in the ER-SLI group with the *highest* receptive language scores were able to use word order cues in the NVN conditions but reverted back to reliance on animacy cues in the NNV and VNN, and that the ER-SLI child with

**Table 4. Percentage first noun choice for all three word order (NVN, NNV, VNN) and animacy conditions (AA, AI, IA) for a subset of the children**

| | NVN | | | NNV | | | VNN | | |
|---|---|---|---|---|---|---|---|---|---|
| | AA | AI | IA | AA | AI | IA | AA | AI | IA |
| E-SLI 7 | 67 | 100 | 50 | 100 | 100 | 17 | 100 | 67 | 0 |
| ER-SLI 1 | 83 | 83 | 83 | 33 | 67 | 33 | 33 | 67 | 33 |
| ER-SLI 3 | 83 | 100 | 33 | 33 | 83 | 17 | 33 | 83 | 0 |
| ER-SLI 7 | 50 | 33 | 67 | 50 | 50 | 50 | 40 | 50 | 17 |

the most severe expressive and receptive deficits exhibited performance that was predominantly at chance levels. Previous research has demonstrated differences in processing deficits that vary along a continuum of *severity* of receptive language deficits (Evans 1996, Evans *et al.* 1997). The findings from this study reflect this pattern as well.

In a review of processing deficits in SLI, Bishop (1992) has argued that one would predict that children with SLI will have particular difficulties in contexts where critical information is transient, or where transient representations must be held in memory while additional information is processed. The children in this study with *lower* scores on language tests which tap auditory memory skills had more difficulties using word order cues to process sentences. Although auditory memory skills were not assessed directly in this study, recently, researchers have proposed deficits in working memory as a possible account of SLI (Gathercole and Baddeley 1990). The findings from this study suggest that deficits in auditory memory might result in the child having problems retaining the sequential order of the words in a sentence long enough to use syntactic (e.g. word order) information during comprehension.

With respect to the second question of whether the subgroups differed across low versus high cue conflict conditions, the children with E-SLI in this study differed qualitatively from the children with ER-SLI, as well as from their normal peers. The E-SLI children exhibited a strong first noun preference across the low and high cue conflict conditions as did their age-matched peers. On the other hand, the children with ER-SLI relied on animacy cues regardless of competing word order cues. In the VNN-AA condition, however, the pattern for both groups of SLI differed from the normal 7 year old's performance in interesting ways. The 7 year olds were clearly sensitive to the absence of word order or animacy cues in this condition, whereas the E-SLI children continued to use a *first noun* strategy and in the absence of word order cues, the ER-SLI chose the *last noun heard*.

The model of language processing employed in this study is one where the acquisition of morphosyntactic knowledge is viewed as the result of the interaction between the pragmatic and semantic demands of the communication interaction coupled with the competing constraints on the speech channel. Speakers must rely on a small set of forms (lexical items, word order, morphological markers, and intonation) to map all possible competing meanings and speaker intentions on to the linear speech stream. As Kirchner and Skarakis-Doyle (1983) have suggested, the child with language disorders must contend with these same communicative task demands, but due to the incomplete acquisition of surface forms, tenuous control over these forms, and possibly limited processing capacity, the communicative system of these children may be qualitatively different, and children with SLI may adapt by employing compensatory strategies or alternative means of processing information. In this study, it is seen that the children with E-SLI appeared to use an adaptive *strict* first noun strategy regardless of sentence type. This strategy differed from that of 7 year old normal children, who switched to an OSV strategy in the NNV context and who appeared to be *thrown* by the absence of cues in the VNN-AA context. On the other hand, the ER-SLI children used semantic knowledge as opposed to syntactic information, a pattern that differed not only from the CA matches but from the younger normal language children as well.

Leonard (1995) has suggested that it is not the grammatical knowledge that is impaired in these children, but their ability to process linguistic information. For a subset of the children in this study, changes in comprehension strategies were observed with increased processing demands from low to high cue competing contexts. In the low cue competing contexts, these children used word order cues, but in the high cue conflict conditions, these children switched to using animacy cues. This suggests, that for at least some children with SLI, when processing demands do not exceed their available resources they may be able to use grammatical information such as word order to interpret sentences correctly, but when processing demands exceed resources in high cue conflict conditions, they may switch and rely on earlier developmental strategies (e.g. whole world knowledge) instead.

The findings from this study have several important clinical assessment implications. First, the findings from this study indicate that children with SLI are not merely delayed in sentence comprehension abilities, but that by the age of 7 have developed adaptive strategies to processing language in real time. The within-group differences in sentence comprehension styles observed in this study also indicate that SLI is not an homogeneous population but one that appears to vary with severity of receptive language abilities. Detailed analysis of novel sentence forms (e.g. VNN-AA) revealed that the E-SLI group's comprehension strategies differed qualitatively from those of age-matched peers by making a more rigid use of the word order strategy. If the null cue condition had not been included, the E-SLI group's sentence comprehension strategies would have appeared unimpaired. This suggests that for children with good receptive language skills, assessment of comprehension skills using highly familiar (e.g. SVO) sentence forms may indicate the apparent absence of comprehension deficits, yet these children may still be experiencing comprehension difficulties in the real-time language processing of novel or unfamiliar sentence forms.

A second important clinical implication was the correlation between children's use of word order cues and their performance on standardized tests requiring good auditory memory skills. For SLI children with poor receptive language abilities, impairments in auditory working memory may prevent them from *attending to* word order cues, cues that require the child to *hold* in auditory memory the serial order of the components of the sentence in real time while simultaneously processing the semantic content of the sentence. For these children with ER-SLI, clinical interventions are needed which focus on developing comprehension strategies that use word order as opposed to 'whole world' information. In contrast, for children with E-SLI, clinical interventions may be needed that target word order patterns where an arbitrary first noun strategy will result in comprehension errors, specifically in those instances where cues are placed in direct competition (e.g. OSV form such as 'the homework the 5th graders will complete is in the yellow folder').

The results from this study provide preliminary support for a processing based account of deficits in subgroups of children with SLI, indicating that in contexts where processing demands are low, E-SLI children may *appear* unimpaired but in contexts where cues are in conflict or where sentence forms are novel, their deficits become evident when compared to typically developing children. In contrast, semantic whole world knowledge-based strategies characterize the language processing skills of children with more severe receptive language deficits regardless of changes in language processing demands. To further clarify these issues, however, future research is needed to address not only the relationship between possible processing capacity limitations and comprehension deficits in subgroups of SLI, but also to investigate the possible role of auditory memory deficits on SLI children's comprehension processing abilities.

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## Appendix

| Nouns: animate | Nouns: inanimate | Verbs |
|---|---|---|
| cow | cup | kisses |
| camel | spoon | hugs |
| cat | chair | pets |
| horse | comb | chases |
| pig | ball | wants |
| lamb | block | |
| monkey | | |
| lion | | |
| zebra | | |

*Examples of sentence types*

| | |
|---|---|
| NVN—AA | The zebra pets the lamb |
| NVN—IA | The block hugs the lion |
| NVN—AI | The pig kisses the cup |
| NNV—AA | The pig the cow pets |
| NNV—IA | The ball the horse hugs |
| NNV—AI | The cow the block chases |
| VNN—AA | kisses the pig the cow |
| VNN—IA | Hugs the comb the monkey |
| VNN—AI | wants the cow the cup |