Auditory lexical decision in children with specific language impairment

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1. Introduction

Children with specific language impairment (SLI) have documented lexical problems in production; for example they are slower in naming task (e.g., Lahey & Edwards, 1996, Leonard, Nippold, Kale, & Hale, 1983) and make more errors in repeating pseudo-words (e.g; Gathercole & Baddley, 1990; Kamhi & Catts, 1986). At the same time, several evidence show that lexical processing on the receptive side in SLI is not speared. This is an important issue, because word recognition is crucial to understand spoken language and problems at this level could be at the basis of comprehension problems in SLI. Present experimental evidences are contrasting and do not reveal how and to what extent children with SLI have a deficit in spoken word recognition.

One of the first studies addressing this issue (Sininger, Klatzky & Kirchner, 1989) showed a slower scanning speed for children with SLI (mean age 11 years) compared with age peers, in a task where subjects had to recognize a word between several words stored in short term memory. It shows that children with SLI have problems to retrieve words from short-term working memory. However, the study did not address lexical retrieval from long-term memory.

More recently, Dollogan (1998) and Montgomery (1999) presented converging evidences suggesting that children with SLI do not have general problems in lexical mapping. Both studies used a gating paradigm to investigate lexical mapping and showed that children with SLI and age peers did not differ in the total amount of sensory information needed to recognize familiar words.

Some studies addressed this issue looking at how spoken words are recognized within sentence context (Montgomery, Scudder, & Moore, 1990; Stark & Montgomery, 1995). In this task children with SLI are slower than normal language developing children in recognizing a sentence-embedded word, suggesting that they have inefficient lexical retrieval (or latter stage of word recognition). The same paradigm was used to test whether temporal speech processing limitation in SLI could interfere with the autonomous pre-lexical process (Montgomery, 2002) -lexical contact and lexical activation in the reviewed cohort theory (Frauenfelder & Tyler, 1987; Marslen-Wilson & Zwiterslood, 1989). The temporal processing demand of different sentences was manipulated using sentences with either an high proportion of brief duration stop consonant or an high proportion of nonstop consonant; overall results showed slower response time for children with SLI (mean age 8;3 years) than age-matched children and younger children matched on receptive syntax (mean age 6;7). Besides, children with SLI did not have particular difficulties to process sentences incorporating high temporal processing demand. Results were interpreted as supporting the hypothesis that children with SLI have diminished general processing capacity.

It is worth noting however that sentence embedded word monitoring-paradigm does not exclusively probe lexical processes –acoustic-phonetic analysis and lexical activation, lexical retrieval and selection-, but it is also sensitive to post lexical processes such as lexical integration, i.e. problems with all the routines responsible for generating phrase or clause level thematic representation (e.g. Nakano & Blumstein, 2004; Swaab, Brown & Hagoort, 1997). For instance, Montgomery and colleagues (Montgomery et al., 1990) evidenced that children with SLI are slower than controls in recognizing sentence embedded words in well formed sentence, but not when words were randomly presented, suggesting problems in using semantic and syntax to speed word recognition, but otherwise demonstrating that children with SLI had no specific problems to identify auditory presented words.

Therefore, it seems important to consider lexical processing out of sentence context. To our knowledge at least two studies explicitly addressed this issue using a simple lexical decision task with children with SLI. The first one (Edwards & Lahely, 1996) considered a group of 20 children with SLI with both expressive and receptive disorders (SLI-mix) (mean age 8;0), a group of 10 children with SLI with only expressive disorder (SLI-exp) (mean age 7;0) and a group of 46 age-matched children. Children with SLI-mix but not children with SLI-exp, were slower than normal language developing children. Besides, children with SLI were comparable to control children with pseudo-words. These results suggest that children with SLI with comprehension problems have inefficient (slower) lexical retrieval than normal children; nonetheless it is not clear in this study whether lexical processing is appropriate for the vocabulary level or not.

A more recent study (Crosby, Howard & Dodd, 2004) examined spoken-word recognition in 15 children with SLI (mean age 8;11) and normally developing children matched separately for age and receptive vocabulary ability (mean age 6;10). Children with SLI were less accurate and found harder to reject non-words, than accepting real words, but were not slower than both control groups. These results are at odd with several previous results in literature (Edwards & Lahely, 1996; Montgomery & Leonard, 1998; Stark & Montgomery, 1995) and were interpreted as supporting the hypothesis that children with SLI have underspecified acoustic-phonetic representations.

2. Our study

The present study further investigates lexical processing in children with SLI with comprehension deficit, addressing the following experimental questions. (1) Is lexical processing in SLI simply delayed or rather some aspects of lexical processing are behind vocabulary level? To answer this first question the performance of a group of 15 French-speaking children with SLI in an auditory lexical decision task is compared with that of 15 age-matched children and that of 15 normal language developing children matched on receptive vocabulary. If children are simply delayed in lexical development no significant difference should emerge when compared to receptive vocabulary matched children. It is worth noting that the auditory lexical decision task and the receptive vocabulary measure taps two different levels of processing; the last one requires well-specified phonological representation and rapid lexical activation while the former requires differentiation of semantically related words.

(2) Does the lexical processing deficit in SLI depend on underspecified auditory-phonetic representations (as claimed by Crosbyet al., 2004) or on inefficient lexical processing (as claimed by Edwards & Lahely, 1996)? We hypothesize that if children with SLI have problems at the level of acoustic-phonetic analysis, non-words should sometime provide enough activation to select the representation of a real word: children with SLI should thus judge non-words as real words more often than normal language developing children. On the contrary, deficit at lexical level -for instance inefficient lexical retrieval or inefficiently organized lexicon- predicts that children with SLI should be slower, but not necessary less accurate than normal children.

Moreover, to make sure that that children with SLI are not slower or less accurate cross the board than their peer, a non-verbal sound detection task and sound discrimination task were used.

3. Method

3.1. Subjects

Forty-five French-speaking children were recruited from primary schools in the region of Wallonie, the French-speaking region of Belgium to participate in the research.

Children with SLI (SLI). 15 children with SLI (mean age 10;8, range: 8;9-14;8). Twelve were boys, three were girls. All the children were diagnosed by speech and language therapists as having specific language impairment and have been tested with two standardized test of oral language for French: the ECOSSE (receptive grammar, French adaptation of the TROG) and the EVIP (French version of the Peabody). Their language performance was at least 1.5 SD below the age-appropriate language performance level as measured by the ECOSSE. The row scores obtained in the EVIP were used to match a group of children on receptive vocabulary (M = 85.9, SD = 22). All children with SLI fell within the normal range of Performance IQ on the Wechsler Intelligence Scale for Children-revised; Wechsler; 1974 (M = 98, SD = 8, range = 87-125). Hearing was within normal limits verified using pure tone hearing screening (20dB HL at 500, 1000, 2000 and 4000 Hz). No neurological dysfunctions were signaled in the clinical history of any of the children. None of the children had history of psychopathology. Finally, no bilingual children were included in the study.

Vocabulary matched control children (RVC). 15 normally developing children served as vocabulary-matched controls (twelve were boy). These children have been matched basing on the raw scores of *EVIP* (M = 83.7; SD = 17). They were younger than children with SLI (M = 7;7). No hearing problems, or low IQ were reported.

Age matched control children (NLC). The AC children consisted in fifteen age control (four were girls) matched to the children with SLI for age mean age 10;5, range between 9;1 and 13;8.

3.2. Procedure

Three tasks were proposed to the children: (1) a non-linguistic sound detection task; (2) a non-linguistic sound discrimination task; (3) an auditory lexical-decision. The order of the experiments was fix: from 1 to 3. Each child was tested individually in a quiet room in the school he or she attended. The experiment was run using the E-prime experimental software, on a Fujitsu-Siemens 3600 MHz laptop. Items within each task were presented in a random order over the speakers at a comfortable listening level. Responses were given using an ergonomic response box with two response keys with the green right key for the target sound or the real word, and the red left key for non-target sounds or pseudo-words following different tasks. Responses were recorded online and included accuracy and response time. The child was seated in front of the computer at approximately 40-60 cm from the screen, the experimenter seat next to the child. During the experiment the examiner started each trial when the child was ready. Five hundred ms before the auditory stimulus onset a fixing point appeared at the center of the screen as well as a reminder of the response keys meaning. Before the experiment begun, children were presented with the instructions from the experiment in the spoken and written form, short after ten trials were provided at the beginning of each task; feedback was provided during the training but not during the experiment.

4. Sound detection task

Stimuli and instructions. Children had to press a key as soon as they heard a target sound (a dog bark lasting for 873 ms). Children were given 10 practice trials and completed 20 experimental trials. The ISI was randomized between 1 and 3 sec, to avoid anticipation effects. The children were encouraged to compete each trial as fast as possible.

Results. Figure 1 shows the mean response times (ms) for the sound detection task for the three groups of subjects. The results showed no significant difference between groups in percentage of missed trials, F<1 or speed to response to a non-sound F<1.

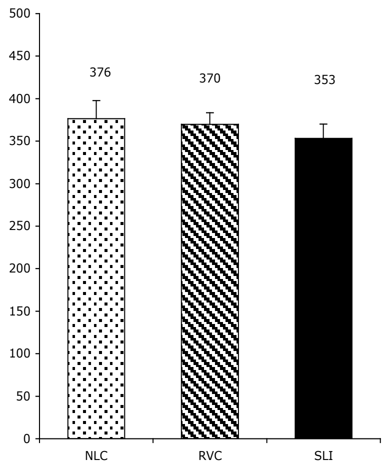

Figure 1. Reaction times in ms in the sound detection task.

5. Sound discrimination task

Stimuli and instructions. Children were instructed to press a key as fast as possible when s/he heard a dog bark and a different key for the other seven different animal sounds (20 target, 30 foils, random ISI 1-3s). Ten practice trials were also given.

Results. Error percentage in the sound-discrimination task were high for all groups (NLC = 97%, RVC = 96% and SLI = 95%) and there was no group difference, F< 1. Figure 2 shows decision times for the three groups (for correct answers only), no group difference emerged, F<1.

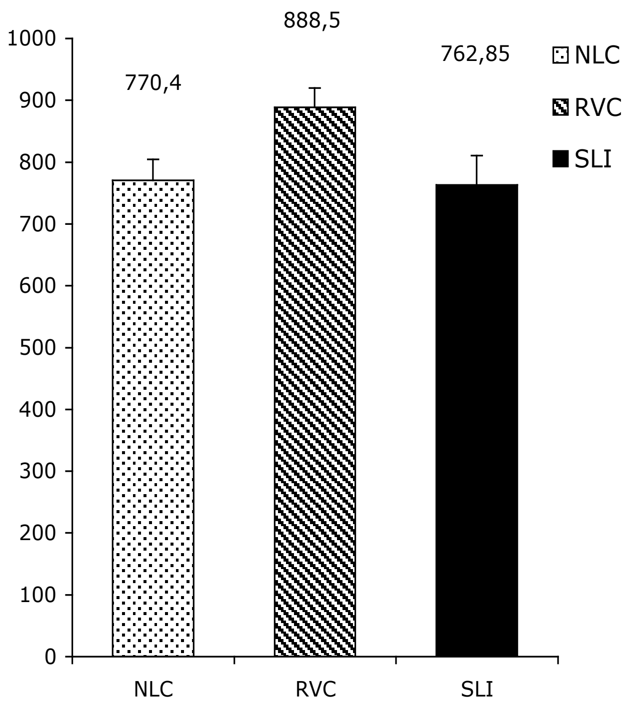

Figure 2. the decision times (ms) in the sound discrimination task.

6. Auditory lexical decision task

Stimuli and instructions. The stimuli in the auditory lexical-decision task included 42 target real words (RW), 26 fillers real words and 68 pseudo-words (PW). All real words were selected to be early acquired, high frequent and highly imageable (basing on database for French, Brulex, Content, Radeau, & Mousty, 1991). The pseudo-words were all legal strings in French and were matched with real words for length in terms of number of phonemes, syllable and duration. For the auditory lexical-decision task, the children were instructed to press the green key as fast as possible when they heard a word that they knew and the red key when they heard a funny word that does not exist or that they did not know. Ten practice trials with feedback were provided; the practice trials were repeated if the child had not understood the task or committed too many errors. The experiment was split in five blocks, whose order was randomized together with the order of the items within blocks. A pause was allowed between each block. The experiment was administrated in one session that lasted for about 15 minutes.

Results and discussion. Figure 3 presents the results for the three groups in terms of accuracy and reaction times for real words and pseudo-words. Consider accuracy first: a mixed-model analysis of variance (ANOVA) was computed where word type (real word and pseudo-word) was the within subject factor and group the between factor. The results showed that there was no group effect, $F < 1$. Besides, in general more errors were committed with pseudo-words than with real-words $F(2, 42) = 52.269$, $p = .000$. No interaction word type by group emerged $F < 1$. Response times for correct answers were entered into a two ways analysis of variance with repeated measures (group: SLI vs. NLC vs. RVC word type: real word vs. pseudo-word). The results showed a significant effect of group $F(2, 42) = 3.530$, $p = .038$. Planned comparison showed no differences between the children with SLI and RVC children ($F<1$), whereas a significant difference emerged between children with SLI and NLC children $F(2, 28) = 5.145$, $p = .031$. Besides, there was a significant effect of word type, with longer reaction times for pseudo-words than real words $F(2,42) = 104.961$, $p = .000$. The interaction word-type by group was not statistically significant $F(2, 42) = 1.428$, $p = .158$.

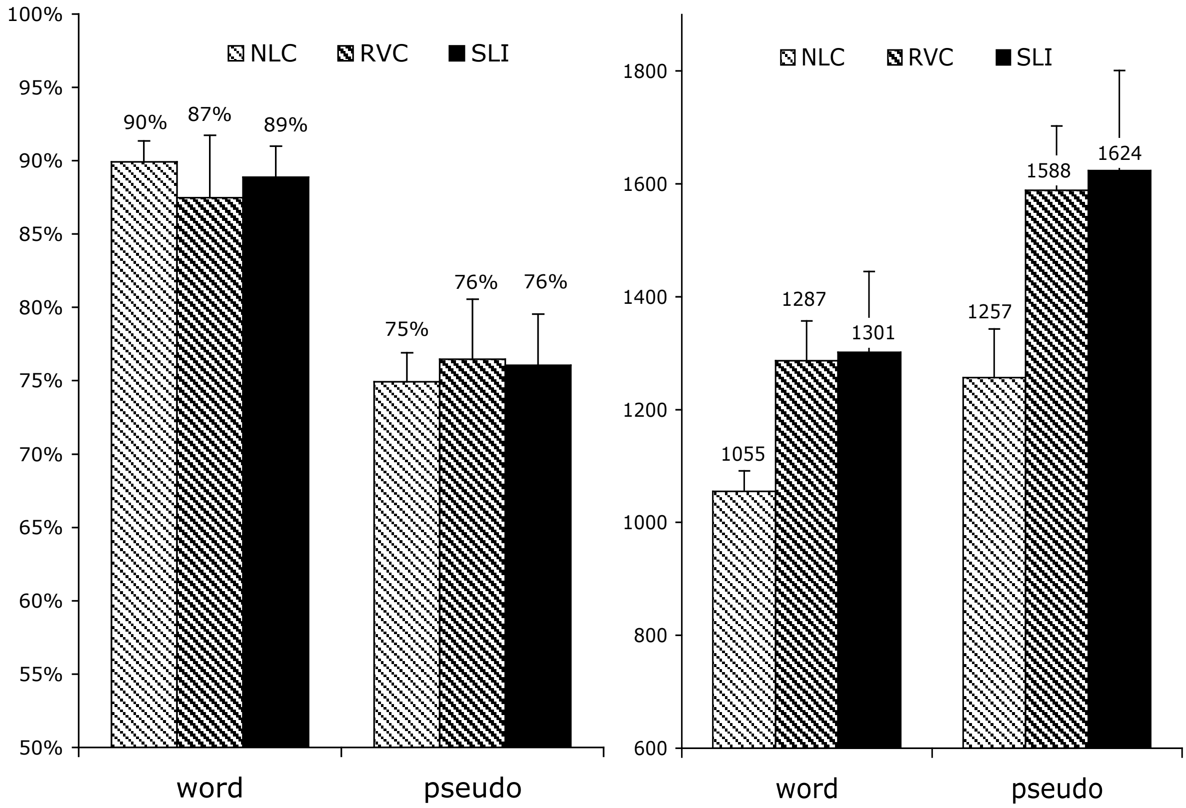

Figure 3. (a) accuracy in the lexical decision task for the three group. (b) decision time (ms) for the three group for words and pseudo-words.

Speed-accuracy trade off. This analysis aimed at ruling out the possibility that results could depend on strategic effect; for instance one group of children could have favored accuracy over speed (or vice versa). No partial correlation between accuracy and reaction time for real words for age-matched group emerged, r = .345, p = .208, vocabulary matched controls, r = .025, p = .930 or for children with SLI r = .125, p = .590 and for pseudo-words, again for age-matched group, r = .234, p = .405, vocabulary matched controls, r = .215, p = .442 or for children with SLI r = -0.44, p = .877. This shows that the observed difference between subjects was reflecting real differences in reaction times and accuracy and not speed-accuracy trade-off differences.

7. Discussion

In this study we further investigated lexical processing in children with SLI compared to two groups of normal language developing children. The accuracy and speed of spoken-word recognition was evaluated using a simple lexical decision task; as previously evidenced in literature lexical processing in children with SLI is not appropriate to their age (Edwards & Lahely, 1996; Montgomery et al., 1990; Montgomery & Leonard, 1998; Stark & Montgomery, 1995; Montgomery, 2002). The present study shows that differences concern response times rather than accuracy. No significant difference emerged between our group of French children with SLI and two control groups in terms of accuracy: they were as accurate as control peers in accepting real-words and refusing pseudo-words. Despite the fact that they were not less accurate, they were slower than age-matched peers. On the other side they were as fast as receptive vocabulary matched children in the lexical decision task.

Yet, these problems appear not to reflect general broad-spectrum slowness, since in the sound detection and sound discrimination tasks the response times of of children with SLI were comparable to that of the age-matched and vocabulary-matched children.

The theoretical questions that motivated this study were the following ones:

Is lexical processing in SLI simply delayed or rather some aspects of lexical processing are behind vocabulary level? The results support the claim that though in children with SLI, lexical processing is not appropriate to their age, it is correct for their vocabulary level. More specifically, it is shown that acoustic-phonological representation is not deficient for their vocabulary level -if it was the case the percentage of accepted pseudo-words should have been higher for children with SLI than receptive vocabulary matched children. Yet, since no latency difference was observed between children with SLI and vocabulary peers, lexical retrieval and lexical organization seems to be appropriate for their vocabulary level. Thus, children with SLI seems to be delayed and not deviant from the lexical developmental pattern.

Do the problem of word recognition in SLI compared with age-matched peers depend on underspecified auditory-phonetic representations or inefficient lexical processing? Children with SLI were slower but not less accurate than expected for their age. This suggests that compared to children of the same age they have an inefficiently organized lexicon or inefficient lexical retrieval mechanisms but not gross problems in the acoustic-phonetic analysis (cf. Crosby t al. 2004). In order to determine whether or not they have subtle deficit in acoustic-phonetic analysis a deeper analysis and more accurate manipulation of the acoustic, phonetic and phonological characteristics of the stimuli employed would be necessary.

Overall these results are consistent with previous findings showing slow lexical processing in children with SLI and within normal limits acoustic-phonetic processing (e.g. Dollogan, 1998; Edwards & Lahely, 1996; Montgomery, 1999; Montgomery, 2002; Montgomery & Leonard, 1998; Stark & Montgomery, 1995). On the other hand, our results that children with SLI are not slower than vocabulary matched children to decide whether a word is a real word or a pseudo contrast with some results previously reported by Montgomery et al. (1990) and Stark and Montgomery (1995) that showed that children with SLI are slower even than vocabulary matched peers. However, these results were obtained using a sentence embedded word recognition paradigm. The fact that children with SLI are worse at recognizing words in sentence context than in isolation suggests that the mechanisms of lexical integration and/or thematic integration are particularly troublesome in SLI. We are at present addressing this question testing the same group of children with SLI using a lexical decision task and looking in details at thematic integration processing.

Results reported here are more difficult to reconcile with data recently reported by Crosby at al. (2004), who showed that children are not slower but less accurate than normal peers especially with pseudo words. The differences between the two studies are not easly explainable. One point is that our group of children with SLI was older; they might be out of the developmental period during which children with SLI show a relatively poor lexical processing. Yet, one other issue is the heterogeneity of the profile of children with SLI, different children could show different problems. Detailed studies of individual variation in acoustic-phonetic and lexical activation, retrieval and selection are needed to establish whether and how many different profiles it is possible to isolate.

Concluding, despite limitations discussed above, it seems that at least certain children with SLI and in a certain developmental period are delayed in lexical processing, that nonetheless is appropriate for their vocabulary level.

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