Journal of Communication Disorders 45 (2012) 20–34

Contents lists available at SciVerse ScienceDirect

Journal of Communication Disorders

Auditory word recognition of nouns and verbs in children with Specific Language Impairment (SLI)

Llorenç Andreu [a,b], Monica Sanz-Torrent [b,*], Joan Guàrdia-Olmos [c,d]

[a] Cognitive Neuroscience and Information Technologies Research Program, IN3,Universitat Oberta de Catalunya, Catalunya, Spain
[b] Department de Psicologia Bàsica, Universitat de Barcelona, Catalunya, Spain
[c] Department de Metodologia i Ciències del Comportament, Universitat de Barcelona, Catalunya, Spain
[d] Research Institute on Brain, Cognition and Behaviour (IR3C), Universitat de Barcelona, Catalunya, Spain

ARTICLE INFO

Article history:
Received 5 March 2011
Received in revised form 14 August 2011
Accepted 27 September 2011
Available online 5 October 2011

Keywords:
Language processing
Language development
Specific language impairment
Word recognition
Verb argument structure

ABSTRACT

Nouns are fundamentally different from verbs semantically and syntactically, since verbs can specify one, two, or three nominal arguments. In this study, 25 children with Specific Language Impairment (age 5;3–8;2 years) and 50 typically developing children (3;3–8;2 years) participated in an eye-tracking experiment of spoken language comprehension to compare the dynamics of spoken word recognition for nouns and verbs in Spanish. Listeners' eye movements were recorded as they searched an array of pictures in response to hearing a noun or verb. Results showed significant an *animacy effect* before the word was finished as images that contain more animate entities attracted their looks which suggest an underdevelopment suppression mechanisms inhibition. Moreover, after word finished all the groups showed differences between nouns and verbs. They were faster in recognizing nouns than verbs and one-argument were recognized faster than two- and three-verb arguments whereas. Children with SLI were slower that their controls and especially in the recognition of three-argument verbs. We suggest that this was due to an incomplete argument structure representation that affects processing times.

Learning outcomes: (1) As a result of this activity, the participant will be able to describe the differences between adults and children with and without SLI in spoken word recognition of nouns and verbs. (2) As a result of this activity, the participant will be able to describe the animacy effect.

1. Introduction

Most theories of lexical processing assume that the recognition of a lexical item results in the automatic activation of a range of syntactic and semantic knowledge that is relevant to language interpretation and reference (e.g. Carlson & Tanenhaus, 1988; Marslen-Wilson, 2007; Moss, Tyler, & Taylor, 2007; Seidenberg, 2007). This lexical knowledge includes syntactic category information (e.g. noun, verb, adjective), combinatory syntactic information (e.g. the number and types of syntactic complements the word assigns), non-combinatory semantic information (animacy, etc.) and combinatory semantic information (the number and types of semantic entities, or arguments/roles). And indeed, ample behavioral

* Corresponding author at: Department de Psicologia Bàsica, Universitat de Barcelona, Passeig de la Vall d'Hebron, 171, 08035 Barcelona, Catalunya, Spain. Tel.: +34 93 312 51 50.
E-mail address: monicasanz@ub.edu (M. Sanz-Torrent).

0021-9924/$ – see front matter © 2011 Elsevier Inc. All rights reserved.
doi:10.1016/j.jcomdis.2011.09.003

evidence exists that this sort of information is activated in real-time, as a function of the frequency and contextual relevance of this information (e.g. Allopenna, Magnuson, & Tanenhaus, 1998; Altmann & Kamide, 1999; Melinger & Koenig, 2007; Novick, Kim, & Trueswell, 2003; Trueswell & Kim, 1998).

From this view, verbs are fundamentally different from nouns. Nouns can refer to objects that have a constant shape and form across time. Verbs, on the other hand, refer to states, actions, or processes that can vary across both time and space. Verbs are also more complex than nouns semantically and syntactically, since verbs can specify one, two, or three nominal arguments in roles such as agent, theme, recipient, goal, or experiencer. For example, the verb "*to give*" specifies a first argument in the subject role, a second argument in the recipient role, and a third argument in the object role, as in the sentence, "John gave his mother a flower." Several studies have found that the sheer amount of information activated, impinges negatively on the processing time for a lexical item (e.g. Gennari & Poeppel, 2003; McElree, Traxler, Pickering, Seely, & Jackendoff, 2001).

On this vein, there is one language disorder that is characterized by developmental delays in verbal abilities that are not accompanied by nonverbal cognitive deficits, namely Specific Language Impairment (Bishop, 1997; Leonard, 1998). Verbs have been proposed as an area of special difficulty for these children (Bishop, 1997; Conti-Ramsden & Jones, 1997; Verhoeven & Van Balkom, 2004) because a common characteristic of them is a substantial delay in the use and understanding of functional morphology. SLI children's speech is characterized as having greater than normal misuse and dropping of inflectional morphology (-s, -ing) and closed class function words -the, a, etc. (Leonard, 1995; Leonard, Eyer, Bedore, & Grela, 1997; Rice & Wexler, 1996, 1997; Rice, Wexler, & Cleave, 1995). Moreover, several studies have shown that children with SLI omit obligatory arguments more often compared to age-matched controls (Fletcher, 1991; Roberts, Rescorla, & Borneman, 1994) and make errors in a much wider variety of verbs compared to MLU-w-matched controls (King & Fletcher, 1993). Children with SLI use significantly fewer argument types (Thordardottir & Weismer, 2002) and omitted more grammatical subject arguments in ditransitive sentences than in sentences with intransitive and transitive verbs (Grela, 2003). In these sense, a recent article in Catalan- and Spanish children with SLI (Sanz-Torrent, Andreu, Badia, & Sidera, 2011) describes three studies of the verb production and argument structure using different methodologies (an observational study which uses a spontaneous-talk longitudinal sample, a sentence-naming task as a result of event video observation and an experimental sentence-naming task with static images that differ in verb argument complexity). Although the specific data vary according to the methodology used, they found clear evidence that Catalan- and Spanish-speaking children with SLI have special difficulties in producing verbs with a highly complex argument structure and make more mistakes in specifying obligatory arguments.

Previous studies have studied the ability of recognize words in children with SLI. Using a word-monitoring paradigm, Montgomery, Scudder, and Moore (1990), Stark and Montgomery (1995) and Montgomery (2000, 2002) have found that children with SLI (mean age approximately 8 years) are slower than their typically developing age-matched peers at recognizing words embedded in a sentence, suggesting that they have less efficient lexical retrieval abilities. In order to reveal the unique contributions of word recognition, a number of studies have used isolated words. Edwards and Lahey (1996), for example, examined children with SLI in an auditory lexical decision task and found that language impairment was associated with a slower responses, but that the magnitude of slowing did not predict the severity of the impairment (see also Lahey, Edwards, & Munson, 2001). While such results could be accounted for by generalized slowing, gated stimuli (e.g. Grosjean, 1980) offer a glimpse into the time-course of processing that is less sensitive to speed of processing. In gated word-recognition paradigm participants hear increasingly longer portions of a spoken word. Research this task has shown that children with SLI do not differ from controls when recognizing frequent real words (Dollaghan, 1998; Montgomery, 1999). Dollaghan (1998) examined listeners with SLI and typically developing listeners as they heard progressively longer portions of isolated familiar words and newly learned (unfamiliar) words. There was no group difference for familiar words, but children with SLI required more acoustic material to recognize newly learned words. Montgomery (1999) used only highly familiar words in a similar paradigm and found no differences between language-impaired and typically developing children on either measure. These findings are also consistent with recent results from gated lexical identification tasks (Mainela-Arnold, Evans, & Coady, 2008). They found children with SLI as a group do not appear to show large deficits in the speed of lexical identification. Marshall and van der Lely (2008) draw similar conclusions about a subclass of children with SLI (G-SLI, Grammatical SLI children, who have particular trouble with morphology). In that study, they found that early aspects of verb recognition were not impaired in G-SLI children, though some differences were observed in later gate positions, which interacted with verb morphology. Recently, Pizzioli and Schelstraete (2011) investigated the lexico-sematic activation in French children with SLI using a auditory pair-primed paradigm (PPP) where participants made a lexical-decision on the second word of a noun pair that could be related (e.g. door-window) or not (e.g. banana-window) to the first one. Results showed that children with SLI presented a larger priming effect in terms of both reaction time and accuracy. Authors suggested that during development children with SLI are more dependent on lexico-semantic information than typically developing children.

There are two major types of explanations for the problems found in children with SLI. On the one hand, some investigations attribute their difficulties to deficits in semantic representations. This hypothesis is based on the idea that the degree of knowledge represented in child's semantic lexicon makes words more o less vulnerable to retrieval failure. Children with SLI exhibit slower speeds of lexical processing and more naming errors as compared with their peers in picture naming (e.g. Andreu, Sanz-Torrent, Buil, & MacWhinney, under review; Lahey & Edwards, 1996; Leonard, Nippold, Kail, & Hale, 1983) and in word recognition experiments (Edwards & Lahey, 1996). Moreover, they showed slower mean latencies and lower accuracy rates than controls in auditory verb recognition (Royle, Jarema, & Kehayia, 2002). These errors have been argued to be due to an impoverished semantic representation in the semantic lexicon (e.g. Capone & McGregor, 2005; McGregor & Appel, 2002; McGregor, Newman, Reilly, & Capone; 2002; Sabisch, Hahne, Glass, von Suchodoletz, & Friederici, 2006).

A second type of account attributes their deficits to processing limitations (e.g. Weismer, Evans & Hesketh, 1999; Leonard, 1998; Miller, Kail, Leonard, & Tomblin, 2001; Montgomery, 2000). The most obvious problems that might be cast in terms of processing capacity limitations came from trade-offs between performance and task complexity observed during language processing tasks. The problems focus on tasks that require word recall and retrieval. Thus, they are frequent errors such as word omissions increase with sentence complexity. In this sense, several studies have emphasized that children with SLI are slower in the amount of work that can be accomplished in a given unit of time. Then, they are slower than normal on simple picture-naming tasks (Katz, Curtiss, & Tallal, 1992; Lahey & Edwards, 1996; Leonard et al., 1983).

Some of the previous studies, though important and useful for the emerging picture of SLI processing, have some important limitations. In particular, these tasks require subjects to make overt responses, such as button-box responses, and reflect linguistic judgments that are not typical of real-time interpretation. In addition, these studies sometimes present subjects with discontinuous words, such as the snippets of linguistic input used in lexical gating tasks. These task properties could mask or even exaggerate SLI processing difficulties. One paradigm that provides information about online language processing involves the recording of eye movements while the child is viewing the scene and listening to the narrative simultaneously. The use of real-time measures of spoken language processing, particularly the so-called 'visual world paradigm' (Cooper, 1974; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995), may offer a better picture of the linguistic processing abilities of children with SLI. With the advent of head-mounted and remote eye tracking systems, it is now relatively easy to obtain a moment-by-moment record of where children and adults are looking as they hear sentences that describe their visual referent world (Trueswell, 2008). Based on this paradigm, there is only one auditory word recognition eye tracking study in children with SLI (McMurray, Samelson, Lee, & Tomblin, 2010). McMurray et al. examined adolescents diagnosed with SLI (average age 17 years) and focused on their phonological processing of nouns in isolation (out of sentence context). In an elegant use of the TRACE model of word recognition (McClelland & Elman, 1986), it was concluded that SLI adolescents show specific deficits in lexical decay, without any deficit in the initial activation of lexical information. In particular, early looks to target referents were similar to controls, but later looks were atypical and more distributed among phonological competitors.

On this basis, the purpose of the present study is to exanimate the dynamics of spoken word recognition for nouns and verbs in children with and without Specific Language Impairment (SLI), specifically we sought to examine if typically developing children and children with SLI are faster to identify targets in response to nouns as compared to verbs. We therefore examine how the degree of verb complexity influences processing times, and whether this factor systematically increases response times with respect to nouns. The generalized slowing hypothesis (Kail, 1994) predicts that SLI children's anticipatory eye movements ought to, at the very least, be slowed relative to age-matched controls. Moreover, it may be that words with a greater number of arguments take longer to retrieve because more grammatical information, such as verbal arguments, is encoded in the lexicon. Then, words that require more grammatical information may take longer time to retrieve and this will explain the differences between nouns and verbs and between verbs that differ in their argument structure. In children with SLI, if they dispose of limited processing capacities, the effect of argument-structure complexity is expected to be larger than in control children with normal language because, more complex words may overwhelm the system's capacity, resulting in competition for resources among different stages of language processing and thus generating a computational trade-off that would benefit early stages of language processing and burden later ones.

On the other hand, the incomplete semantic representations approach predicts that higher frequency forms will be produced and accessed more accurately, while lower frequency forms that have not been memorized will not be produced appropriately and will be significantly more difficult for children with SLI to recognize as compared to controls. Therefore, if their verb semantic representations are impoverished is expected that the latency will increase not necessarily increase as the verb's argument structure.

2. Experiment 1

2.1. Method

2.1.1. Participants

All participants were native Spanish speakers and had normal or uncorrected-to-normal vision. Three groups took part in this study. The first one consisted of 25 children (18 boys, 7 girls) with Specific Language Impairment (SLI), with age ranging from 5;3 to 8;2. The second group consisted of 25 children matched on age with the children with SLI (18 boys, 7 girls), ranging 5;3–8;2. The third group consisted of 25 children (18 boys, 7 girls) matched on Mean Length of Utterance by words (MLU-w) with the children with SLI (18 boys, 7 girls), ranging from 3;3 to 7;1. Ethical approval was obtained from the University of Barcelona and parents of children gave their written informed consent for their participation in this study.

Table 1
Group age, cognitive measures and performance on language.

	Group		
	SLI group	Age controls	MLUw controls
	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)
Age (years)	6.69 (0.90)	6.72 (0.92)	5.51 (1.05)
NVIQ	95.8 (7.9)	106.3 (6.0)	93.13 (9.32)
PPVT-III	78.52 (9.36)	112.07 (14.37)	92 (12.87)
ELI-phonetics[a]	6.37 (4.27)	2.12 (2.23)	4.47 (3.87)
ELI-receptive vocabulary[a]	36.27 (18.84)	73.07 (17.97)	67.85 (26.13)
ELI-expressive vocabulary[a]	8.62 (1.8)	60.38 (15.06)	52.27 (28.84)
ELI-pragmatics[a]	53.64 (25.99)	80.38 (15.60)	62.56 (14.34)
MLUw	3.89 (1.39)	6.86 (1.76)	3.97 (1.45)

Note. Chronological age in years; NVIQ (Nonverbal Intelligence quotient) in standard score (mean = 15; SD: 15); PPVT-III (Peabody Picture Vocabulary Test III, Spanish version) in standard score (mean = 15; SD: 15); ELI (Evaluación del Lenguaje Infantil); ELI-phonetics in mean of number of errors; ELI-Receptive vocabulary; ELI-expressive vocabulary and ELI-pragmatics in percentiles; MLU-w (mean length of utterance by words).
[a] Values only calculated with the children younger than 6 years old.

The children with SLI were selected according to standard criteria for diagnosing SLI (Leonard, 1998; Stark & Tallal, 1981; Watkins, 1994). SLI is defined as a developmental language disorder in the absence of clear neurological, sensori-motor, non-verbal cognitive or social emotional deficits that can affect both expressive and receptive language. Tests included the Wechsler Intelligence Scale for Children (WISC-R; Spanish version; Wechsler, Cordero, & de la Cruz, 1993) or the Kaufman Brief Intelligence Test (KBIT, Kaufman & Kaufman, 2004). Every child with SLI obtained a nonverbal IQ standard score above 85. Language ability was assessed by language profiles following the Spanish protocol for evaluation of language delay (AREL, Pérez & Serra, 1998), the Spanish version of Peabody Picture Vocabulary Test III (PPVT-III, Dunn, Dunn, & Arribas, 2006) and the child language scale (Evaluación del Lenguaje Infantil, ELI; Saborit & Julián, 2005). The ELI test includes several subtests for phonetics, lexical reception, lexical production and pragmatics. Children with SLI had scores of at least a -1.25 standard deviation below the mean in Peabody III or some subtest of ELI. Language profiles based on transcripts of spontaneous conversations provided information about the characteristics of the language production of the children, from which it was found that they showed a delay of at least one year (see Bishop, 1997). We also calculated the MLU value in words of each child. Each child passed a hearing screening at for each ear (25 dB at 500, 1000, 2000 and 4000 Hz). None of the children that take part in the study had problems in the hearing any pure tone in normal frequency ranges. With respect to neurological dysfunctions, the case histories of all the children were seen by an educational psychologist, to rule out any evidence of cerebral palsy or brain damage. With respect to oral structure and motor function, speech therapists examined the children to assess the shape, size and motor function of the speech organs, both active (tongue, lips and jaw) and passive (buccal cavity, palate and teeth); as well as respiratory dynamics, exhalation and rhythm. Motor function was assessed according to a protocol that used different practical exercises to verify that mobility was normal. With respect to physical and social interactions, the educational psychologists drew up a report containing information about each child's family background and aspects of his/her personality such as self-esteem, sense of self confidence and confidence in others, level of socialization, social abilities, degree of anxiety, etc. This information was used to verify that each child had no symptoms of impaired reciprocal social interaction or any restriction of activities. In addition, all the children selected for the study had been diagnosed with Specific Language Impairment (SLI) by speech and language therapist of the school educational psychology services and were receiving language intervention.

The age control group was equivalent in age (same year and ± 2 months) and mother tongue (Spanish) to their counterparts in the SLI group. Teachers were asked if the control subjects' language development was normal for their age. Children were not selected if they had a history of speech therapy or psychological therapy. Moreover, teachers were asked to select children with normal academic performance. All of the children selected came from state schools in Catalonia and Valencia. With respect to the MLU-w Control group, each child in the study group was paired with another child according to their linguistic level, measured from the MLU in words (± 0.6 words), sex and mother tongue. In addition, nonverbal intelligence and language ability was assessed of all children selected in both age control and MLU group using the same tests and protocols that in children with SLI group. A summary of descriptive data for the three groups of children is presented in Table 1.

2.1.2. Stimuli

Eighteen nouns and eighteen verbs (six one-argument, six two-argument and six three-argument verbs) were selected as target words. Target words were matched across groups for number of syllables such that there were the same number of monosyllabic (one), disyllabic (13) and trisyllabic words (four) both in the noun and verb condition (2.16 mean syllables), with each verb group having the same mean syllable length of 2.16.

Target words were also assessed for: (1) frequency in the LEXESP corpus (Sebastián, Martí, Carreiras, & Cuetos, 2000) of written Spanish; (2) age of acquisition in the Serra-Solé corpus (Serra, Solé, Serrat, Bel, & Aparici, 2000) using the program FREQ of the CLAN of the CHILDES project (MacWhinney, 2000); and (3) imageability from published rating norms (Valle-Arroyo, 1999). As seen in Table 2, nouns did not differ from verbs in any way except for imageability. As expected, nouns were rated as more imagable than verbs (see, e.g. Gillette, Gleitman, Gleitman, & Lederer, 1999 for a similar effect in English). As

Table 2
Mean properties of nouns and verbs (SD) and (range) in parentheses. *F*-Ratios reflect effect of syntactic category.

	Nouns (*N* = 18)	Verbs (*N* = 18)	*F*-Ratio test
Frequency	47.84 (49.46) (4.64–172.14)	44.75 (57.80) (1.79–249.11)	$F(1,34) = 0.024$, $p = 0.880$
Age of acquisition	22.89 (5.92) (18–30)	23.55 (5.38) (18–30)	$F(1,34) = 0{,}108$, $p = 0.746$
Imageability	6.29 (0.34) (5.77–7.00)	4.87 (1.18) (1.07–6.38)	$F(1,34) = 24.17$, $p < 0.001$
Label appropriateness	6.26 (0.67) (4.32–6.97)	4.37 (0.73) (3.35–5.93)	$F(1,34) = 63.08$, $p < 0.001$

Table 3
Mean properties of verb classes (SD) and (range) in parentheses. *F*-Ratios reflect effect of verb class.

	One-argument (*N* = 6)	Two-argument (*N* = 6)	Three-argument (*N* = 6)	*F*-Ratio test
Frequency	41.52 (26.68) (17.14–84.82)	38.63 (35.04) (1.79–102.5)	54.11 (96.21) (4.46–249.11)	$F(2,15) = 0.065$, $p = 0.938$
Age of acquisition	21.33 (5.32) (18–30)	28.17 (3.60) (21–30)	21.17 (4.35) (18–29)	$F(2,15) = 3.706$, $p = 0.123$
Imageability	5.56 (0.65) (4.9–6.38)	4.12 (1.58) (1.07–5.42)	4.94 (0.74) (3.64–5.8)	$F(2,15) = 2.72$, $p = 0.10$
Label appropriateness	4.63 (0.92) (3.52–5.93)	4.18 (0.50) (3.35–4.68)	4.29 (0.83) (3.61–5.39)	$F(2,15) = 0.57$, $p = 0.58$

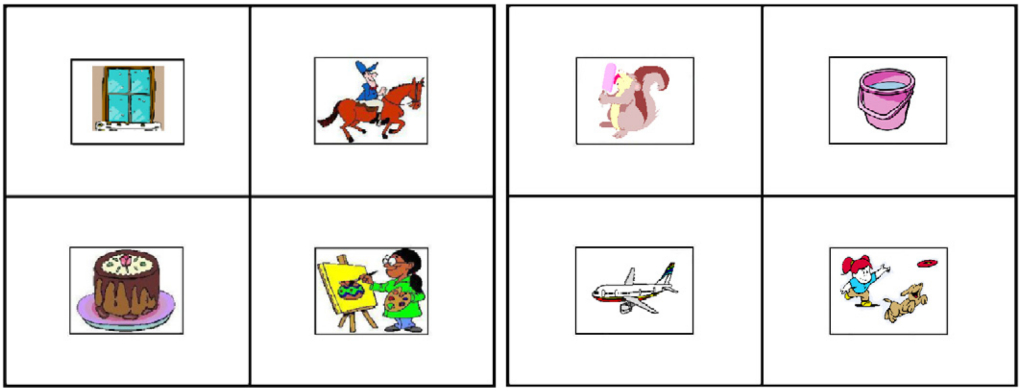

Fig. 1. Stimuli example. Target noun: cake; competitors: noun: window, verbs: to ride (two-argument verb) and to paint (two-argument verb). Target verb: to lick (one-argument verb); competitors: verb: to throw (three-argument verb) and nouns: plane and cauldron.

can be seen in Table 3, the three verb groups did not differ significantly on any of the properties, including imageability, although there was a marginally significant uncorrected pairwise comparison found between one-argument and two-argument verbs [$t(10) = 2.07$, $p = 0.07$]. Although the number of stimuli in each set of verb types was relatively small (six), this has been the case in other studies investigating verb argument structure (e.g. Ouden, Fix, Parrish, & Thompson, 2009), due to stimulus selection requirements.

Each of the 18 nouns and 18 verbs were paired with a picture depicting the object or action. The pictures consisted of clip art images, which were sometimes altered using a professional image editing software package (see Fig. 1 for examples). In order to determine how well the images depicted the intended object or action, a group of 32 adults rated the appropriateness of each word for the corresponding picture. This was done for each item by showing the picture with the word printed next to it (in singular form for nouns and in the infinitive form for verbs); participants then answered the following question "On a scale from 1 to 7 how good is this as a one-word name for this picture?" As expected nouns were better labels for pictures than verbs (see Table 2, label appropriateness). Crucially however, label appropriateness did not differ significantly between the three verb classes (see Table 3).

Each target picture was then paired with three distracter pictures, such that the resulting set of four images always included two object images and two event images (i.e., noun targets had one object distracter and two event distracters whereas verb targets had one event distracter and two object distracters). Although the distracter pictures were never referred to with names during the experiment, we made sure that what we considered to be common names for these distracter pictures were similar in frequency to the target names. In addition, the onset phoneme of each target word always differed from the onset phoneme of the common names for the three distracters, so to avoid auditory cohort competitor effects (see Allopenna et al., 1998).

Target words were recorded by a male native Spanish speaker and sampled at 44,100 Hz. A digital audio editor was used to adjust the duration of each word to one second while ensuring that all word sounded natural to native speakers. Each trial image consisted of four pictures each placed within four quadrants on the computer screen (see Fig. 1). The background was white and two black lines, one vertical, one horizontal, were used to divide the four quadrants. The position of the target picture and the competitors were randomized and the number of arguments involved in distracter event pictures was balanced across conditions. We carefully selected distracter pictures so that their appearance or similarities in form, function or color were not similar to the targets.

The audio and the visual image for each item were merged together in a video file lasting 4000 ms, using VirtualDubMod software. In each video, the onset of the spoken word coincided with the onset of the visual stimuli. The spoken word finished at 1000 ms from image onset.

2.1.3. Procedure

Participants were seated approximately 22 in. in front of a *Tobii T120* eye tracker with an integrated 17 in. TFT monitor. *Tobii Studio* Software was used to present the stimuli, and collect the eye tracking data. Stimuli videos were 800×600 pixels in size and centered on the screen, which was set to 1024×768 pixels. The visual angle of each object subtended approximately 13°, well above the 0.5° accuracy of the eye tracker. All audio was played over a mono channel split to two loudspeakers positioned on either side of the viewing monitor. Eye position was sampled at 120 Hz (i.e., at 8.333 ms intervals).

A nine point calibration was carried out at the beginning of the experiment. The *Tobii Studio* Software automatically validates calibrations and the experimenter could, if required, repeat the calibration process if validation was poor. Calibration took approximately 20 s. Participants were instructed that for each trial they would see a set of four pictures and hear a single word spoken aloud (a noun in singular form or a verb in infinitive form). Their task was to find the picture mentioned, and then continue looking at the picture until the video disappeared. There were two practice trails before the experimental task (one with a noun target and one with a verb target) to acquaint the participant with the flow of events. The test videos were presented in random order in two blocks containing eighteen words (nine nouns and nine verbs: three of each verb type). Moreover, the pictures in each block were randomized anew for each subject. All the participants were given both blocks. Between each trial, participants were presented with a crosshair centered in the middle of the screen (which they had been instructed to fixate). This position was equidistant from each quadrant and corresponded to the intersection of the two lines that divided the four quadrants. The crosshair was displayed for 2000 ms.

2.1.4. Analysis

An area of interest was defined for each target picture as the set of all screen coordinates that fell within the rectangle surrounding the picture (see Fig. 1). The horizontal and vertical eye position data was then used to determine looks to the target picture. A value of one was given to every eye-tracking sample that fell within the target region, otherwise it was given a zero. Then, for each participant on each trial, the proportion of target-look samples was calculated during two time windows. The first window began 200 ms after the onset of the spoken word (and video) and lasted until the end of the word, which was always 1000 ms. A 200 ms offset was used because the minimum latency to plan and launch a saccade is estimated to be between 150 and 180 ms in simple tasks (Fischer, 1992; Martin, Shao, & Boff, 1993; Saslow, 1967). As such, 200 ms after word onset is approximately the earliest point at which one expects to see looks driven by the acoustic information. The second time window corresponded to 1000–2000 ms, i.e., a one second interval after the word was uttered.

Trials with more than 33% track loss were excluded. The age control group presented 4.93% track loss and 10 trials were dropped. The MLU control group had 5.25% track loss, and 27 images were dropped. Finally, the SLI group had 6.59% track loss and eighteen stimuli were dropped.

2.2. Results

Figs. 2–4 present the proportion of looks over time to the targets referent for control age, MLU and SLI groups. The three black vertical lines divide the two windows of analysis. Analyses of Variance (ANOVAs) were conducted on E-Logit transformations of subject and item means of the proportional data for each window of analysis with group 3 (SLI, control age, MLU controls) by target type 4 (nouns, one-argument, two-argument, three-argument verbs) as factors.

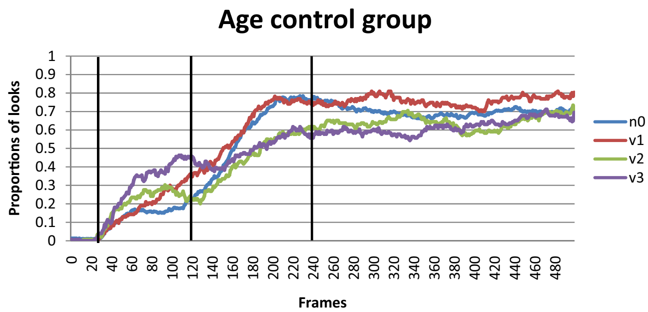

Fig. 2. Proportion of looks to the nouns (n0), one-argument (v1), two-argument (v2) and three-argument verbs (v3) from image and word onset in age control group.

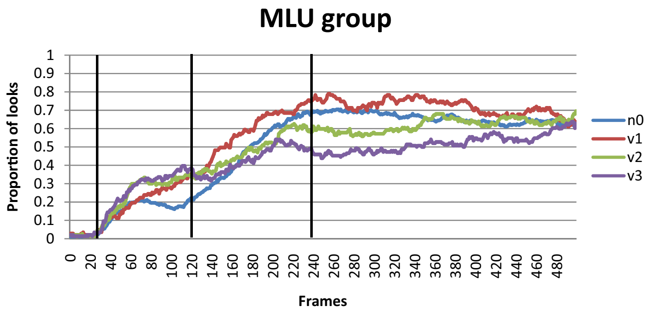

Fig. 3. Proportion of looks to the nouns (n0), one-argument (v1), two-argument (v2) and three-argument verbs (v3) from image and word onset in MLU group.

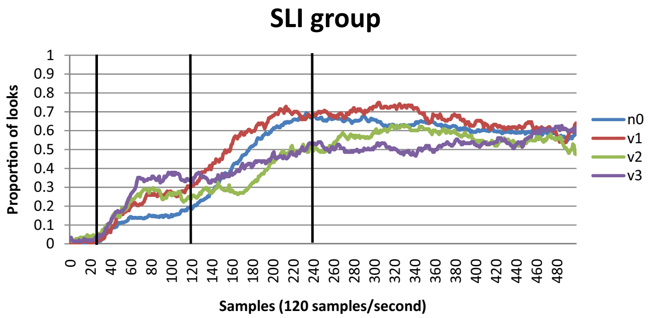

Fig. 4. Proportion of looks to the nouns (n0), one-argument (v1), two-argument (v2) and three-argument verbs (v3) from image and word onset in SLI group.

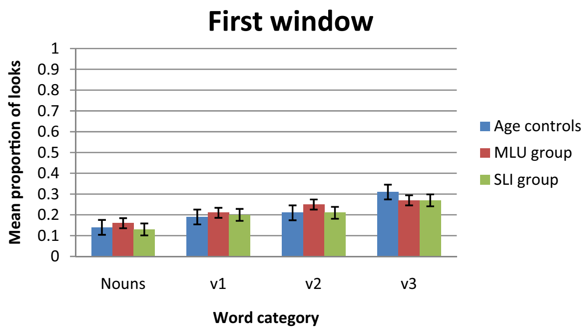

Fig. 5. Proportion of looks to the nouns, one-argument (v1), two-argument (v2) and three-argument verbs (v3) binned into the first window (average of subject means, error bars = 1 S.E).

In the first window of analysis (200–1000 ms), results showed there were significant differences in word category $F_{(3,216)} = 38.019$; $p < 0.01$ ($\varepsilon^2 = .62$); but neither between groups $F_{(2,72)} = .785$; $p = 0.5$ nor interaction effect between group and word category $F_{(6,216)} = 1.305$; $p = 0.3$. All the groups of children showed the same pattern of look. With respect to the differences between the nouns and the three types of verbs, the paired comparison revealed that nouns were different to all verb types. One-argument verbs were equal to two-argument verbs, but different to three-argument verbs. Two-argument were also different to three-argument verbs. Fig. 5 shows the proportion of looks to the all word types referents binned into the first window in each group of the sample.

In sum, in this first window, results revealed that, in general, the animate images, those which represented verbs, received more looks than the object images. Moreover, the proportion of looks increase as a function of the number of animate images was on the picture. Thus, received more looks pictures that represent three-verb argument that those which represent one-verb argument.

In the second window of analysis (1000–2000 ms), results showed there were significant differences in word category $F_{(3,216)} = 26.577$; $p < 0.01$ ($\varepsilon^2 = .532$) and between groups $F_{(2,72)} = 4.138$; $p < 0.02$ ($\varepsilon^2 = .103$). There was also an interaction effect between group and word category $F_{(6,216)} = 3.052$; $p < 0.01$ ($\varepsilon^2 = .119$). In relation to group differences, the paired comparison found differences between the SLI group and the age group.

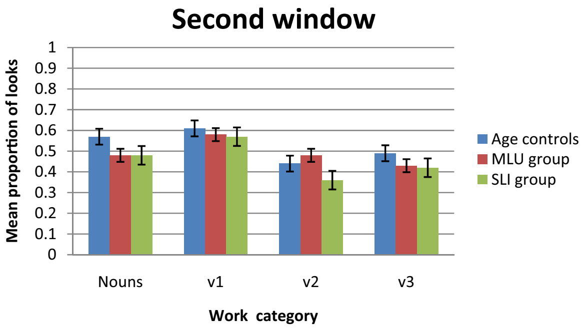

Fig. 6. Proportion of looks to the nouns, one-argument (v1), two-argument (v2) and three-argument verbs (v3) binned into the second window (average of subject means, error bars = 1 S.E.). .

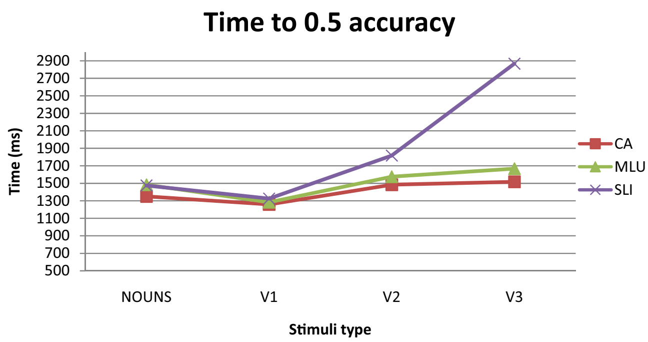

Fig. 7. Time to arrive to 0.5 accuracy to the nouns, one-argument (v1), two-argument (v2) and three-argument verbs (v3) from image and word onset in age matched control, MLU and SLI group.

Table 4
ANOVA (generalized linear model) of time to arrive to 0.5 accuracy to the nouns, alls verbs together, one-argument (v1), two-argument (v2) and three-argument verbs (v3) from image and word onset in age control, MLU and SLI group.

Source of variation	F	df	Sig.	ε^2	$1-\beta$
Condition	2320.754	2,84	<.001	.889	.742
Group	23.816	2,84	<.001	.888	.897
Interaction group by condition	148,095	9,84	<.001	.749	.832

With respect to the differences between the nouns and the three types of verbs, the paired comparison revealed that nouns were different to all verb types. Looks to one-argument were different to two-argument and three-argument verbs. Moreover looks to two-argument and three-verb argument verbs were equal.

Fig. 6 shows the proportion of looks to the all word types referents binned into the second window in each group of the sample. Post hoc contrast (Student–Newman–Keuls) showed that age control group's looks to nouns were equal to looks to one-argument verbs but different with two- and three-argument verbs that were also equal. The MLU group showed differences between looks to nouns and one-argument verbs. Looks to one-argument verbs were different to the looks to the rest of verb types. Looks to two- and three-verb arguments were equal. Finally, in children with SLI we found differences in looks to one- two- and three-argument verbs but three-argument verbs and nouns showed the same pattern.

The age control group showed two patterns of look, one for nouns and one argument verbs and another for two- and three-argument verbs. However, the MLU group and children with SLI showed more heterogeneous pattern of looks between nouns and verbs with different argument structure.

In order to compare the speed processing we calculate the time from image and word onset where all groups arrive to 0.5 value of accuracy. Fig. 7 shows the values for each group and for the different target types.

Table 4 shows the statistical signification of means values of Fig. 7. For to do that, analyses of variance (ANOVAs) were conducted by Group 3 (SLI, MLU, and control age) and by target type 4 (nouns, alls verbs together, one-argument, two-argument and three-argument verbs). Table 4 shows that all the sources were statistical significant and also, with higher effect size (from .742 to .897). In fact, the effect between three groups shown an important difference ($p < 001$) and also we can find as result of repeated conditions ($p < .001$). In both principal effects, all the conditions were statistically significant as consequence the "a posteriori" contrast. In general the SLI group showed a higher mean score in relation to the rest of groups

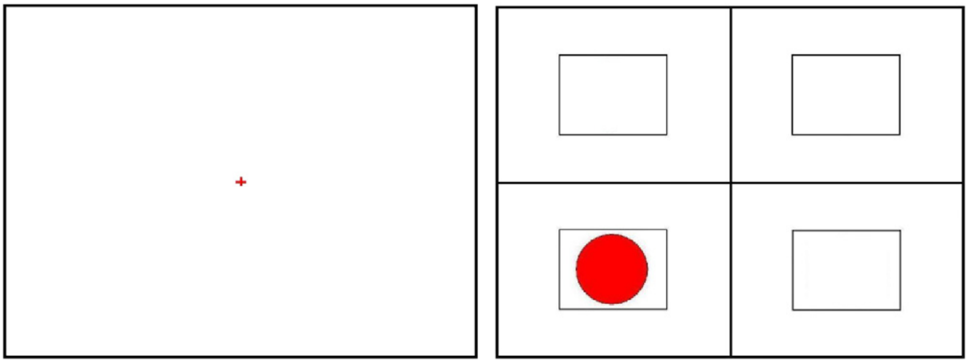

Fig. 8. Stimuli example.

and, obviously, the three-argument verbs implies the highest mean score in relation to the other conditions. An special effect showed the first order interaction ($p < .001$), so implies that the SLI group in three-arguments verbs is the slowest group to arrive to 0.5 value of accuracy and, as a consequence, is the highest mean score combination and the most significant "a posteriori" contrast ($p < .001$).

2.3. Discussion

Results of experiment 1 showed that children with SLI were slower than age matched controls but no differences were found with respect to their MLU controls. This is according with the *processing limitations hypothesis* (Ellis Weismer et al., 1999; Leonard, 1998; Miller et al., 2001; Montgomery, 2000). This hypothesis suggests that children with SLI are slower in the amount of work that can be accomplished in a given unit of time. But in the task reported in this study, the slowness showed by the children with SLI can be due to low perceptual or motor processing instead of high level processing. During children heard a word they were forming meaning about it and then searched the pictured that represent the concept. Thus, it could be that children with SLI were not slower processing the linguistic input but searching visual signals. In visuospatial attentional orienting, a covert movement of attention, independently of the overt movements of the eyes, takes place in order of a few tens of milliseconds and after approximately 200 ms, over orienting a saccade may follow the covert orienting (Groner & Groner, 1989).

3. Experiment 2

In order to check if the slowness observed in the previous experiment by the SLI group was due to a slower linguistic processing or to slowness in visual and motor processing we carried out other experiment. This experiment was as similar as possible as the previous but instead of using a task based on an input linguistic was made purely visual processing.

3.1. Method

3.1.1. Participants

The same participants as in the previous experiment took part in this.

3.1.2. Stimuli

We use the same structure that in the previous experiment. We made four images that had the background white and two black lines, one vertical, one horizontal were used to divide the four quadrants. In every image, there was one red dot inside of one quadrant. Every image had the red dot in one different quadrant (see Fig. 8).

3.1.3. Procedure

The same that in the previous experiment but participants were instructed here: "You'll see some pictures with one red dot. Try to look as fast as you can the red dot". The images were presented in random order. Each image was presented four times in random order in two blocks containing eight images. Between each trial, participants were first presented for approximately 2000 ms with a crosshair (which they had been instructed to fixate) so that the direction of gaze on each trial would start from the same point (the center of the screen that corresponded with the intersection of the two lines that divided the four quadrants).

3.1.4. Analysis

The horizontal and vertical eye position data obtained from the Tobii Studio Software were used to assess eye position. A value of one was given to every eye-tracking sample that fell within the quadrant with the red dot inside; otherwise it was

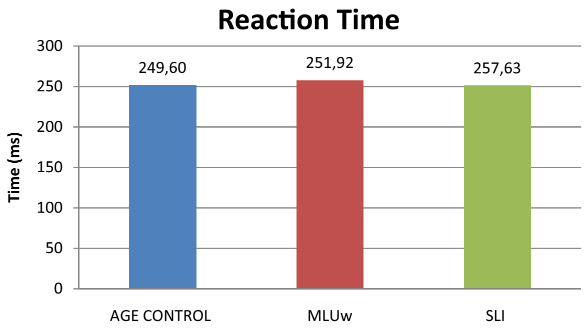

Fig. 9. Reaction times for age-matched controls, MLU-w controls and children with SLI.

given a zero. From this we calculated the proportion of looks made by the participants to the target and the distracters. We rejected trials which there was more than 33% loss of track of eye position data. After exclusion of these trials, subjects who did not have at least 50% of the trials for each condition were removed. The mean percent of track loss in the age control group presented with 3.57% track loss and twelve trials dropped. The MLU control group had 3.29% track loss, 11 trials dropped. The SLI group had 4.59% track loss and thirty stimuli dropped.

3.2. Results

Fig. 9 shows the mean value of reaction time for each group. We analyzed the time from image onset to first inspection to red dot quadrant. There were no statistically significant differences between group means as determined by one-way ANOVA [($F(2, 69) = .362$; $p = .698$)].

3.3. Discussion

Results of experiment 2 showed that children with SLI did not differ in the speed of recognition of simply visual stimuli. Thus, the slowness showed by children with on search the correct image SLI in experiment 1 was not due to perceptual or motor factors but linguistic processing.

3.4. General discussion

The purpose of the current study was to investigate the dynamics of spoken word recognition for nouns and verbs abilities of Spanish-speaking children with Specific Language Impairment (SLI). To do so, children with SLI's eye movements were recorded as they searched an array of pictures in response to hearing a noun or verb. Results showed an animacy effect in the visual exploration before the word was finished for all the groups of children. Moreover, after word finished all the groups showed differences between nouns and verbs. They were faster in recognizing nouns than verbs and one-argument were recognized faster than two- and three-verb arguments whereas. Children with SLI were slower that their controls and especially in the recognition of three-argument verbs.

3.4.1. Animacy effect

The visual exploration of the scene, before the word finished, revealed that all the groups of children showed an animacy effect. Children started looking to the pictures that contained the representation of people doing an event. Then, in general, drawings that had more participants received more looks, and pictures with objects (that represent nouns) were the least looked. Children were more influenced initially by pictures with people, which attracted their looks even after word onset when they went to look for the representations of the word they had heard. As previous studies have showed, people and even animate objects attract a disproportionate number of fixations (Buswell, 1935; Castelhano, Weith, & Henderson, 2008; Friedman, 1979; Yarbus, 1967). Moreover, different studies with infants have shown that they fixate on the eyes of a face more than any other facial feature (Maurer, 1995; Morton & Johnson, 1991) and have also been shown to use the gaze of others as well as body and head movements and orientation to redirect their attention appropriately (Butler, Caron, & Brooks, 2000; Entremont, Hains, & Muir, 1997; Scaife & Bruner, 1975). In this work, we found that animacy directs the orientation of the eyes, especially in scenes perceived by children.

This *animacy effect* suggest children around five year-old present an underdevelopment in suppression mechanisms inhibition and suppression processes because they cannot inhibit this effect which attracted their looks to the images that contain more animate entities. Although both inhibition of a proponent response and resistance to distracter interference develop with age, there is emerging evidence that their developmental trajectories differ. Jones, Rothbart, and Posner (2003) observed a dramatic increase in the ability to inhibit responses in pre-school children. They found that the ability to inhibit an action in a Simple Simon task increased from 22% to 90% between 3 and 4 years of age. In contrast, resistance to distracter interference develops at a much slower rate and continues to develop through the preteen years (Bjorklund & Harnishfeger, 1990). As a result, relative to older children, young children are more likely to attend to task-irrelevant information (Higgins & Turnure, 1984; Lane & Pearson, 1982).

Because the development in suppression mechanisms co-occurs with the development of language a number of studies support the possibility that they interference for language learning. Researchers have also documented positive relationships between inhibition and language functioning (Bishop & Norbury, 2005; Wolfe & Bell, 2003). In addition, it has been shown that distractions negatively impact speech perception (Polka, Rvachew, & Molnar, 2008), word learning (Dixon, Salley, & Clements, 2006). In our study, we found that the control of resistance to distracter interference (look at animates entities) impacted negatively in the speed of auditory verb recognition.

Although recent investigations of children with specific language impairment (SLI) have observed difficulties in maintain attentional control in situations involving irrelevant and contradictory stimuli in order to determine whether suppression skills (problems in sustained selective attention) (e.g. Dodwell & Bavin, 2008; Noterdaeme, Amorosa, Mildenberger, Sitter, & Minow, 2000; Spaulding, Plante, & Vance, 2008) and attentional shifting (Lum, Conti-Ramsden, & Lindell, 2007; Noterdaeme et al., 2001) no differences were found in the animacy effect suppression between these children and their controls.

3.4.2. Processing of nouns and verbs with different argument structure

Despite the bias for participants to look at pictures containing animate entities over inanimate ones (all nouns targets in this study were inanimate objects) found in window 1 and in other studies (e.g. Boland, 2005) that could affect the starting point of looks of window 2, the results show that all the groups of children recognize faster nouns than verbs. Moreover, they spend more time to recognize one- than two- and three-argument verbs. The lack of differences found between two and three argument verbs can be explained by the fact that all potential alternative argument structures are activated each time a verb is uttered (see Shapiro, Zurif, & Grimshaw, 1987). This was even found in a picture naming task where the picture constraints the interpretation (Kim & Thompson, 2000; Shapiro & Levine, 1990; Thompson, Lange, Schneider, & Shapiro, 1997). All of the two- and three- argument verbs that we selected for our study can accept both two and three argument structures and this may explain why we did not find differences between them.

As regards group differences, children with SLI were slower than age matched controls but no differences were found with respect to their MLU controls. This is according with the *processing limitations hypothesis* (Ellis Weismer et al., 1999; Leonard, 1998; Miller et al., 2001; Montgomery, 2000). However, previous research in word recognition had found contradictory results. Some studies using a word-monitoring paradigm (Montgomery, 2000, 2002; Montgomery et al., 1990; Stark & Montgomery, 1995) found that children with SLI are slower than their typically developing age-matched peers at recognizing words embedded in a sentence. In addition, a study using the lexical decision task found significant differences in response latencies between children with SLI and control groups (Edwards & Lahey, 1996). On the other hand, gated word-recognition studies found that children with SLI do not differ from controls when recognizing frequent real words (Dollaghan, 1998; Mainela-Arnold et al., 2008; Marshall & van der Lely, 2008; Montgomery, 1999). However, the task properties of these studies could mask or even exaggerate SLI processing difficulties. The visual world eye tracking method offers some improvements, especially for the study of children with developmental disorders; spoken word recognition can be analyzed along with a near-continuous measure of a natural behavior (look at what is being talked about). The lack of an overt button box response may be especially advantageous for the study of SLI, given findings from Schul, Stiles, Wulfeck, and Townsend (2004), who report dissociation in children with SLI between visual-motor responses which are generally slowed, and visual-attentional shifting, which appears to be unimpaired. Our work, using the visual world eye tracking method showed the same sort of slowing and that those found in word-monitoring studies but differ from those based on gating tasks. Thus, our results suggest the possibility that previous studies, based on offline methodologies, not only tapped word recognition abilities but also other factors such as working memory limitations or visual-motor response limitations.

Children with SLI exhibited a developmental delay, in that their proportion of looks to target referents were substantially lower than age-matched controls and very similar to (younger) MLU-matched controls. Our suspicion is that this difference between children with SLI and age-matched controls reflects a delay in linguistic knowledge. In this regard, Bjorklund (1987) argued that growth in the content and organization of semantic memory influences the ease with which information can be retrieved. He posited that lexical items that are encoded robustly in terms of semantic features and semantic relationships have lower activation thresholds during retrieval. Thus, one likely candidate is that children with SLI (and MLU-matched controls) have slightly smaller verb lexicons or are less certain of the semantics of some verbs as compared to age-matched controls. This explanation would predict the pattern observed here, in which there is a similar time-course of processing accompanied with different asymptotic performance (see McElree, Pylkkänen, Pickering, & Traxler, 2006, for discussion in terms of speed accuracy tradeoff)—there are simply fewer trials on which children with SLI and MLU-matched controls perform accurately as compared to age-matched controls. Then, the differences in auditory word recognition found between each group of children and, if we compare these results with those found in previous studies with adults in which verb processing becomes more difficult as the number of arguments entailed by the verb's representation increases (e.g. Den Ouden et al., 2009; Kim & Thompson, 2000, 2004; Thompson et al., 1997), suggest that children are building their semantic representations of verbs. This poorer linguistic representation may affect their time of processing and explain the differences found with adults. Previous studies have found that children with SLI have impoverished semantic representation in the child's semantic lexicon (Kail & Leonard, 1986; McGregor et al., 2002; McGregor & Appel, 2002). In this sense, some studies have suggested yet that children with SLI have an incomplete argument structure representation (e.g. Thordardottir &

Weismer, 2002) and a study of ERPs revealed that they show weaker lexical-semantic representations of the verb and their selectional restrictions (Sabisch et al., 2006).

Finally, our results are showed similar results that the other auditory word recognition eye tracking study in children with SLI (McMurray et al., 2010). In this study, McMurray et al. found that adolescents with SLI (average age 17 years) showed fewer looks to the target and more fixations to the cohort and rhyme competitors. These results were compared to a number of variants of the TRACE model (McClelland & Elman, 1986) that were constructed to test a range of theoretical approaches to language impairment: impairments at sensory and phonological levels; vocabulary size, and generalized slowing. None of the existing approaches were strongly supported, and variation in lexical decay offered the best fit. This conclusion is similar to our results with younger children with SLI (average about age 7 years) that we suggest that reflects a delay in linguistic knowledge as a result of their poorer linguistic verb argument representations.

The results obtained in this research raise important clinical implications for the intervention of children with SLI. The fact that children with SLI have smaller verb lexicons or impoverished semantic representations of some verbs could be the basis for some of their language problems. It may well be that the difficulties that children with SLI have in understanding and forming sentences stem from representational problems in the semantics of the verbs in those sentences. On one hand, in language comprehension, several processing models have supported the importance of lexical constraints for anticipating and activating incoming information (e.g. Altmann & Steedman, 1988; MacDonald, Pearlmutter, & Seidenberg, 1994). Moreover, several studies have demonstrated that verb argument structure and other aspects of our combinatory lexical knowledge play an important role in guiding sentence comprehension (e.g. Boland, Tanenhaus, & Garnsey, 1990; Ferreira & McClure, 1997; Garnsey, Pearlmutter, Myers, & Lotocky, 1997; Konieczny, Hemforth, Scheepers, & Strube, 1997; Trueswell, Tanenhaus, & Garnsey, 1994; Trueswell, Tanenhaus, & Kello, 1993). On the other hand, in language production, the semantics of a verb plays a crucial role because the activation of a verb lemma also implies the retrieval of other information necessary for sentence production. In this sense, information regarding argument structure will help children produce a sentence that contains all the obligatory constituents for that particular verb in that particular context. If children do not have a complete knowledge of the semantics of the verb, they may produce a variety of errors as regards omission of obligatory arguments and substitution of correct arguments (Bowerman & Brown, 2007; Gropen, Pinker, Hollander, & Goldberg, 1991). Thus, language intervention should focus on providing a greater number of experiences with verbs (in different contexts and with alternations of different argument structures) which will help children enrich the degree of knowledge represented in their semantic lexicon and thus will benefit their ability in language comprehension and production. Future research should explore the role of verb argument structure in the language difficulties found in children with SLI and its potential effects on language intervention.

In sum, an auditory word recognition study is reported to investigate the argument structure effects in children with Specific Language Impairment (SLI). The results indicate that the problems children with SLI are slower and less accurate than their controls especially in three argument verbs. The empirical data of this study suggest that these problems are due to problems with the semantic representation of verb argument structure that affects processing times.

Appendix A

List of nouns and verbs used as stimuli in experiment 1.

Nouns	One-argument verbs	Two-argument verbs	Three-argument verbs
Árbol [*Tree*]	Bailar [*to dance*]	Abrir [*to pen*]	Atar [*to tie*]
Avión [*Plane*]	Caer [*to fall*]	Coger [*to catch*]	Dar [*to give*]
Cama [*Bed*]	Caminar [*to walk*]	Chupar [*to lick*]	Enseñar [*to teach*]
Coche [*Car*]	Dormir [*to sleep*]	Llevar [*to carry*]	Regalar [*to give (a present)*]
Flor [*Flower*]	Llorar [*to cry*]	Recoger [*to pick*]	Contar [*to tell*]
Lámpara [*Lamp*]	Volar [*to fly*]	Tocar [*to play*]	Lanzar [*to throw*]
Lápiz [*Pencil*]			
Llave [*Key*]			
Manzana [*Apple*]			
Mesa [*Table*]			
Muñeco [*Doll*]			
Radio [*Radio*]			
Reloj [*Clock*]			
Silla [*Chair*]			
Sofá [*Sofa*]			
Tarta [*Cake*]			
Tomate [*Tomatoe*]			
Vaso [*Glass*]			

Appendix B. Continuing education

1. What is animacy effect?
   a. tendency to look a cartoon
   b. tendency to look at people or animals
   c. tendency to look at an object animated
   d. tendency to move
2. It is easier to identify the drawings of verbs that names? True/false.
3. Children with SLI are faster processing one-argument verbs and nouns that two verbs and three argument? True/false.
4. Children with SLI were particularly slower than their controls:
   a. Three argument verbs
   b. Two argument verbs
   c. One argument verbs
   d. Nouns
5. Do the authors suggest that the results were due to an incomplete argument structure representation? True/false.

References

Allopenna, P. D., Magnuson, J. S., & Tanenhaus, M. K. (1998). Tracking the time course of spoken word recognition using eye movements: Evidence for continuous mapping models. *Journal of Memory and Language, 38*, 419–439.

Altmann, G. T. M., & Kamide, Y. (1999). Incremental interpretation at verbs: Restricting the domain of subsequent reference. *Cognition, 73*, 247–264.

Altmann, G. T. M., & Steedman, M. J. (1988). Interaction with context during human sentence processing. *Cognition, 30*, 191–238.

Andreu, L., Sanz-Torrent, M., Buil, L., MacWhinney, B. (under review). Verb argument structure usage in children with and without Specific Language Impairment (SLI): Evidence from picture naming. *International Journal of Language & Communication Disorders*.

Bishop, D. (1997). *Uncommon understanding*. London: Psychology Press.

Bishop, D., & Norbury, C. F. (2005). Executive functions in children with communication impairments, in relation to autistic symptomatology: I. Generativity. *Autism, 9*(1), 7–27.

Bjorklund, D. F. (1987). How age changes in knowledge base contribute to the development of children's memory: An interpretive review. *Developmental Review, 7*, 93–130.

Bjorklund, D. F., & Harnishfeger, K. K. (1990). The resources construct in cognitive development: Diverse sources of evidence and a theory of inefficient inhibition. *Developmental Review, 10*, 48–71.

Boland, J. E. (2005). Visual arguments. *Cognition, 95*, 237–274.

Boland, J. E., Tanenhaus, M. K., & Garnsey, S. M. (1990). Evidence for the immediate use of verb control information in sentence processing. *Journal of Memory and Language, 29*, 413–432.

Bowerman, M., & Brown, P. (2007). *Crosslinguistic perspectives on argument structure: Implications for learnability*. Hillsdale, NJ: Lawrence Erlbaum.

Buswell, G. T. (1935). *How people look at pictures*. Chicago: The University of Chicago Press.

Butler, S. C., Caron, A. J., & Brooks, R. (2000). Infant understanding of the referential nature of looking. *Journal of Cognition and Development, 1*, 359–966.

Capone, N., & McGregor, K. K. (2005). The effect of semantic representation on toddlers' word retrieval. *Journal of Speech, Language, and Hearing Research, 48*, 1468–1480.

Carlson, G., & Tanenhaus, M. (1988). Thematic roles and language comprehension. In W. Wilkins (Ed.), *Syntax and semantics, Vol. 21: thematic relations* (pp. 263–289). New York: Academic Press.

Castelhano, M. S., Wieth, M. S., & Henderson, J. M. (2008). I see what you see: Eye movements in real-world scenes are affected by perceived direction of gaze. In L. Paletta & E. Rome (Eds.), *Attention in cognitive systems* (pp. 252–262). Berlin: Springer.

Conti-Ramsden, G., & Jones, M. (1997). Verb use in specific language impairment. *Journal of Speech, Language and Hearing Research, 40*, 1298–1313.

Cooper, R. M. (1974). The control of eye fixation by the meaning of spoken language. A new methodology for the real time investigation of speech perception, memory, and language processing. *Cognitive Psychology, 6*, 84–107.

Den Ouden, D., Fix, S., Parrish, T. B., & Thompson, C. K. (2009). Argument structure effects in action verb naming in static and dynamic conditions. *Journal of Neurolinguistics, 22*, 196–215.

D'Entremont, B., Hains, S., & Muir, D. (1997). A demonstration of gaze following in 3- to 6-months olds. *Infant Behavior and Development, 20*, 569–572.

Dixon, W. E., Jr., Salley, B. J., & Clements, A. D. (2006). Temperament, distraction, and learning in toddlerhood. *Infant Behavior and Development, 29*, 342–357.

Dodwell, K., & Bavin, E. L. (2008). Memory and narratives of children with Specific Language Impairment. *International Journal of Language and Communication Disorders, 43*, 201–218.

Dollaghan, C. (1998). Spoken word recognition in children with and without specific language impairment. *Applied Psycholinguistics, 19*, 193–207.

Dunn, Ll. , Dunn, L. M., & Arribas, D. (2006). *PPVT-III Peabody. Test de Vocabulario en Imágenes*. Madrid: TEA Ediciones.

Edwards, J., & Lahey, M. (1996). Auditory lexical decisions of children with specific language impairment. *Journal of Speech and Hearing Research, 39*, 1263–1273.

Ellis Weismer, S. E., Evans, J., & Hesketh, L. (1999). An examination of verbal working memory capacity in children with specific language impairment. *Journal of Speech, Language and Hearing Research, 42*, 1249–1260.

Ferreira, F., & McClure, K. (1997). Parsing of garden-path sentences with reciprocal verbs. *Language and Cognitive Processes, 12*, 273–306.

Fischer, B. (1992). Saccadic reaction time: Implications for reading, dyslexia and visual cognition. In K. Rayner (Ed.), *Eye movements and visual cognition: Scene perception and reading* (pp. 31–45). New York: Springer-Verlag.

Fletcher, P. (1991). Evidence from syntax for language impairment. In Miller (Ed.), *Research on child language disorders* (pp. 167–187). Austin, TX: Pro-Ed.

Friedman, A. (1979). Framing pictures: the role of knowledge in automatized encoding and memory for gist. *Journal of Experimental Psychology: General, 108*, 316–355.

Garnsey, S. M., Pearlmutter, N. J., Myers, E., & Lotocky, M. A. (1997). The contributions of verb bias and plausibility to the comprehension of temporarily ambiguous sentences. *Journal of Memory and Language, 37*(1), 58–93.

Gennari, S., & Poeppel, D. (2003). Processing correlates of lexical semantic complexity. *Cognition, 89*(1), B27–B41.

Gillette, J., Gleitman, L., Gleitman, H., & Lederer, A. (1999). Human simulation of vocabulary learning. *Cognition, 73*(2), 135–176.

Grela, B. G. (2003). The omission of subject arguments in children with Specific Language Impairment. *Clinical linguistics & phonetics, 17*(2), 153–169.

Groner, R., & Groner, M. T. (1989). Attention and eye movement control: an overview. *European Archives Psychiatry and Clinical Neuroscience, 239*, 9–16.

Gropen, J., Pinker, S., Hollander, M., & Goldberg, R. (1991). Affectedness and direct objects: The role of lexical semantics in the acquisition of verb argument structure. *Cognition, 4*, 153–195.

Grosjean, F. (1980). Spoken word recognition processes and the gating paradigm. *Perception and Psychophysics, 28*, 267–283.

Higgins, A. T, & Turnure, J. F. (1984). Distractibility and concentration of attention in children's development. *Child Development, 55*, 1799–1810.

Jones, L. B., Rothbart, M. K., & Posner, M. I. (2003). Development of executive attention in preschool children. *Developmental Science, 6*(5), 498–504.

Kail, R. (1994). A method for studying the generalized slowing hypothesis in children with specific language impairment. *Journal of Speech and Hearing Research, 37*, 418–421.

Kail, R., & Leonard, L. B. (1986). Word-finding abilities in language-impaired children. ASHA Monographs, No. 25.

Katz, W., Curtiss, S., & Tallal, P. (1992). Rapid automatized naming and gesture by normal and language impaired children. *Brain and Language, 43*, 623–641.

Kaufman, A. S., & Kaufman, N. L. (2004). *KBIT: Kaufman Brief Intelligence Test (KBIT, Spanish version)*. Madrid: TEA Editions.

Kim, M., & Thompson, C. K. (2000). Patterns of comprehension and production of nouns and verbs in agrammatism: Implications for lexical organization. *Brain and Language, 74*, 1–25.

Kim, M., & Thompson, C. K. (2004). Verb deficits in Alzheimer s disease and agrammatism: Implications for lexical organization. *Brain & Language, 88*, 1–20.

King, G., & Fletcher, P. (1993). Grammatical problems in school-age children with specific language impairment. *Clinical Linguistic and Phonetics, 7*, 339–352.

Konieczny, L., Hemforth, B., Scheepers, Ch. , & Strube, G. (1997). The role of lexical heads in parsing: Evidence from German. *Language and Cognitive Processes, 12*(2/3), 307–348.

Lahey, M., & Edwards, J. (1996). Why do children with specific language impairment name pictures more slowly than their peers? *Journal of Speech, Language, and Hearing Research, 39*, 1081–1098.

Lahey, M., Edwards, J., & Munson, B. (2001). Is processing speed related to severity of language impairment? *Journal of Speech, Language and Hearing Research, 44*(6), 1354–1361.

Lane, D. M., & Pearson, D. A. (1982). The development of selective attention. *Merrill-Palmer Quarterly, 28*, 317–337.

Leonard, L. (1995). Functional categories in the grammars of children with specific language impairment. *Journal of Speech and Hearing Research, 38*, 1270–1283.

Leonard, L. (1998). *Specific Language Impairment*. London: The MIT Press.

Leonard, L., Eyer, J., Bedore, L., & Grela, B. (1997). Three accounts of the grammatical morpheme difficulties of English-speaking children with specific language impairment. *Journal of Speech and Hearing Research, 40*, 741–753.

Leonard, L., Nippold, M., Kail, R., & Hale, C. (1983). Picture naming in language-impaired children. *Journal of Speech and Hearing Research, 26*, 609–615.

Lum, J. A. G., Conti-Ramsden, G., & Lindell, A. K. (2007). The attentional blink reveals sluggish attentional shifting in adolescents with specific language impairment. *Brain and Cognition, 63*, 287–295.

MacDonald, M. C., Pearlmutter, N. J., & Seidenberg, M. S. (1994). The lexical nature of syntactic ambiguity resolution. *Psychological Review, 101*(4), 676–703.

MacWhinney, B. (2000). *The CHILDES project: tools for analyzing talk*. Hillsdale, NJ: Lawrence Erlbaum.

Mainela-Arnold, E., Evans, J., & Coady, J. (2008). Lexical representations in children with SLI: Evidence from a frequency manipulated gating task. *Journal of Speech, Language, and Hearing Research, 51*, 381–393.

Marshall, C. R., & van der Lely, H. K. J. (2008). Recognition of gated verbs by children with Grammatical-Specific Language Impairment: Effects of inflection and frequency. *Journal of Neurolinguistics, 22*, 433–451.

Marslen-Wilson, W. D. (2007). Morphological processes in language comprehension. In G. Gaskell (Ed.), *Oxford handbook of psycholinguistics* (pp. 175–193). Oxford: Oxford University Press.

Matin, E., Shao, K. C., & Boff, K. R. (1993). Saccadic overhead: Information processing time with and without saccades. *Perception & Psychophysics, 53*(4), 372–380.

Maurer, D. (1995). Infant's perception of facedness. In T. Field & M. Fox (Eds.), *Social perception in infants*. Norwood: Ablex.

McClelland, J. L., & Elman, J. L. (1986). The TRACE model of speech perception. *Cognitive Psychology, 18*, 1–86.

McElree, B., Traxler, M. J., Pickering, M. J., Seely, R. E., & Jackendoff, R. (2001). Reading time evidence for enriched composition. *Cognition, 78*, B17–B25.

McElree, B., Pylkkänen, L., Pickering, M. J., & Traxler, M. (2006). The time course of enriched composition. *Psychonomic Bulletin & Review, 13*, 53–59.

McGregor, K. K., & Appel, A. (2002). On the relation between mental representation and naming in a child with specific language impairment. *Clinical Linguistics and Phonetics, 16*, 1–20.

McGregor, K. K., Newman, R. M., Reilly, R. M., & Capone, N. (2002). Semantic representation and naming in children with specific language impairment. *Journal of Speech, Language, and Hearing Research, 45*, 998–1014.

McMurray, B., Samelson, V. M., Lee, S. H., & Tomblin, J. B. (2010). Individual differences in online spoken word recognition: Implications for SLI. *Cognitive Psychology, 60*(1), 1–39.

Melinger, A., & Koenig, J. P. (2007). Part-of-speech persistence: Part-of speech category information as an organizing principle in the mental lexicon. *Journal of Memory and Language, 56*, 472–489.

Miller, C., Kail, R., Leonard, L., & Tomblin, B. (2001). Speed of processing in children with specific language impairment. *Journal of Speech, Language, and Hearing Research, 44*(2), 416–433.

Montgomery, J. (2000). Verbal working memory and sentence comprehension in children with specific language impairment. *Journal of Speech, Language, and Hearing Research, 43*(2), 293–308.

Montgomery, J. W. (1999). Recognition of gated words by children with specific language impairment: An examination of lexical mapping. *Journal of Speech, Language, and Hearing Research, 42*, 735–742.

Montgomery, J. W. (2002). Examining the nature of lexical processing in children with specific language impairment: Temporal processing or processing capacity deficit? *Applied Psycholinguistics, 23*, 447–470.

Morton, J., & Johnson, M. (1991). CONSPEC and CONLEARN: A two-process theory of infant face recognition. *Psychological Review, 98*, 164–181.

Montgomery, J. W., Scudder, R. R., & Moore, C. (1990). Language-impaired children's real time comprehension of spoken language. *Applied Psycholinguistics, 11*, 273–290.

Moss, H. E., Tyler, L. K., & Taylor, K. I. (2007). Conceptual structure. In G. Gaskell (Ed.), *Oxford handbook of psycholinguistics* (pp. 217–234). Oxford: Oxford University Press.

Noterdaeme, M., Amorosa, H., Mildenberger, K., Sitter, S., & Minow, F. (2001). Evaluation of attention problems in children with autism and children with a specific language disorder. *European Child and Adolescent Psychiatry, 10*, 58–66.

Novick, J. M., Kim, A., & Trueswell, J. C. (2003). Studying the grammatical aspects of word recognition: Lexical priming, parsing and syntactic ambiguity resolution. *Journal of Psycholinguistic Research, 32*(1), 57–75.

Pérez, E., & Serra, M. (1998). *Analisis del retraso del lenguaje (AREL)*. Barcelona: Ariel.

Pizzioli, F., & Schelstraete, M. (2011). Lexico-semantic processing in children with specific language impairment: The overactivation hypothesis. *Journal of Communication Disorders, 44*(1), 75–90.

Polka, L., Rvachew, S., & Molnar, M. (2008). Speech perception by 6- to 8-month-olds in the presence of distracting sound. *Infancy, 13*(5), 421–439.

Rice, M., & Wexler, K. (1996). Toward tense as a clinical marker of a Specific Language Impairment in English speaking children. *Journal of Speech, Language and Hearing Research, 39*, 1239–1257.

Rice, M., & Wexler, K. (1997). *Highly specified and long-term grammatical deficits appear in children with language impairments*. Department of Brain and Cognitive Sciences, MIT.

Rice, M., Wexler, K., & Cleave, P. (1995). Specific language impairment as a period of extended optional infinitives. *Journal of Speech and Hearing Research, 38*, 850–863.

Roberts, J., Rescorla, L., & Borneman, A. (1994). Morphosyntactic characteristics of early language errors: An examination of specific expressive language delay. *Pòster presented at symposium on research in child language disorders.*

Royle, P., Jarema, G., & Kehayia, E. (2002). Frequency effects on visual word access in developmental language impairment. *Journal of Neurolinguistics, 15*, 11–41.

Sabisch, B., Hahne, A., Glass, E., von Suchodoletz, W., & Friederici, A. D. (2006). Lexical-semantic processes in children with specific language impairment. *Developmental Neuroscience, 17*(14), 1511–1514.

Saborit, C., & Julián, J. P. (2005). *ELI–L'Avaluació del Llenguatge Infantil*. Castelló de la Plana: Universitat Jaume I.

Sanz-Torrent, M., Andreu, L., Badia, I., & Sidera, F. (2011). Argument omissions in preschool Catalan and Spanish speaking children with SLI. *Infancia y Aprendizaje, 34*(1), 49–66.

Saslow, M. G. (1967). Latency for saccadic eye movement. *Journal of the Optical Society of America, 57*, 1030–1033.
Scaife, M., & Bruner, J. S. (1975). The capacity for joint visual attention in the infant. *Nature, 253*, 265–266.
Schul, R., Stiles, J., Wulfeck, B., & Townsend, J. (2004). How 'generalized' is the 'slowed processing' in SLI? The case of visuospatial attentional orienting. *Neuropsychologia, 42*, 661–671.
Sebastián, N., Martí, M. A., Carreiras, M., & Cuetos, F. (2000). *LEXESP. Léxico informatizado del español.* Barcelona: Edicions Universitat de Barcelona.
Seidenberg, M. S. (2007). Connectionist models of reading. In G. Gaskell (Ed.), *Oxford handbook of psycholinguistics* (pp. 235–250). Oxford: Oxford University Press.
Serra, M., Serrat, E., Solé, R., Bel, A., & Aparici, M. (2000). *La adquisición del lenguaje*. Barcelona: Ariel.
Shapiro, L. P., & Levine, B. A. (1990). Verb processing during sentence comprehension in aphasia. *Brain and Language, 38*, 21–47.
Shapiro, L. P., Zurif, E., & Grimshaw, J. (1987). Sentence processing and the mental representation of verbs. *Cognition, 27*, 219–246.
Spaulding, T. J, Plante, E., & Vance, R. B. (2008). Sustained selective attention skills of preschool children with specific language impairment: Evidence for separate attentional capacities. *Journal of Speech, Language, & Hearing Research, 51*, 16–34.
Stark, R. E., & Montgomery, J. W. (1995). Sentence processing in language impaired children under conditions of filtering and time compression. *Applied Psycholinguistics, 16*, 137–154.
Stark, R. E., & Tallal, P. (1981). Selection of children with specific language deficits. *Journal of Speech and Hearing Disorders, 46*, 114–122.
Tanenhaus, M. K., Spivey-Knowlton, M. J., Eberhard, K. M., & Sedivy, J. C. (1995). Integration of visual and linguistic information in spoken language comprehension. *Science, 268*, 1632–1634.
Thompson, C., Lange, K., Schneider, S., & Shapiro, L. (1997). Agrammatic and non-brain-damaged subjects' verb and verb argument structure production. *Aphasiology, 11*, 473–490.
Thordardottir, E., & Weismer, S. (2002). Verb argument structure weakness in specific language impairment in relation to age and utterance length. *Clinical Linguistics & Phonetics, 16*(4), 233–250.
Trueswell, J. C. (2008). Using eye movements as a developmental measure within psycholinguistics. In I. A. Sekerina, E. M. Fernández, & H. Clahsen (Eds.), *Language processing in children*. John Benjamins.
Trueswell, J. C., & Kim, A. E. (1998). How to prune a garden-path by nipping it in the bud: Fast-priming of verb argument structures. *Journal of Memory and Language, 39*, 102–123.
Trueswell, J. C., Tanenhaus, M., & Garnsey, (1994). Semantic influences on parsing: Use of thematic role information in syntactic disambiguation. *Journal of Memory and Language, 33*, 285–318.
Trueswell, J. C., Tanenhaus, M., & Kello, C. (1993). Verb-specific constraints in sentence processing: Separating effects of lexical preference from garden-paths. *Journal of experimental Psychology: Learning, Memory & Cognition, 19*, 528–553.
Valle-Arroyo, F. (1999). *Normas de Imaginabilidad*. Oviedo (Spain): Universidad de Oviedo, Servicio de Publicaciones.
Verhoeven, A. L., & Van Balkom, J. (2004). *Classification of developmental language disorders*. Hillsdale, NJ: Lawrence Erlbaum Associates.
Watkins, R. (1994). Specific language impairments in children: An F introduction. In R. Watkins & M. L. Rice (Eds.), *Specific language impairments in children*. Baltimore: Brookes Publishing.
Wechsler, D., Cordero, A., & de la Cruz, M. V. (1993). *Wechsler Intelligence Scale for children. Revised (WISC-R, Spanish version)*. Madrid: TEA Editions.
Wolfe, C. D., & Bell, M. A. (2003). Working memory and inhibitory control in early childhood: Contributions from physiology, temperament, and language. *Developmental Psychobiology, 44*, 68–83.
Yarbus, I. A. (1967). *Eye movements and vision*. New York: Plenum Press.