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Differential verbal working memory effects on linguistic production in children with Specific Language Impairment

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ABSTRACT

Deficits in verbal working memory (vWM) have often been reported in children with Specific Language Impairments (SLIs) and might significantly contribute to their linguistic difficulties. The linguistic and narrative skills of a group of children with diagnosis of SLI were compared to those of a group of children with typical development. The linguistic assessment included a comprehensive analysis of their lexical, grammatical and narrative abilities. Overall, the participants with SLI had difficulties at all three levels of linguistic processing. The effect of vWM was marginal on lexical processing, significant on grammatical structuring, and null on narrative construction.

1. Introduction

The label Specific Language Impairment (SLI) applies to a cluster of relatively frequent developmental disorders characterized by language delay in children with otherwise normal physical and intellectual development (Leonard, 1998; Newbury, Fisher, & Monaco, 2010). SLI is not a homogenous condition (Laws & Bishop, 2003). As language is a complex cognitive function resting on the interaction between different levels of processing, its development may be affected in different ways. A comprehensive linguistic assessment should include all of these levels of processing and address the delicate issue of their reciprocal interconnections. Generally speaking, language can be analyzed from two major points of view: 1) a within-sentence or microlinguistic level, which focuses on lexical (i.e., phonetic, phonological, morphological and semantic) and grammatical (i.e., morphosyntactic and syntactic) skills; 2) a between-sentence or macrolinguistic level, which focuses on pragmatic (i.e., the ability to generate inferences so to contextualize the literal meanings of words and sentences, and understand the communicative intentions of the interlocutors) and discourse (i.e., the ability to establish linguistically cohesive and conceptually coherent ties) skills. Increasing evidence shows that these levels (and their interrelations) can be simultaneously assessed by adopting a multi-level approach to narrative language analysis (e.g., Marini, Andreetta, del Tin, & Carlomagno, 2011) and that this ensures a comprehensive understanding of the linguistic symptoms observed in both adult patients and children with developmental and/or acquired disorders (e.g., Marini, Tavano, & Fabbro, 2008; see also Botting, 2002 for further considerations on the usefulness of narrative as a tool for the assessment of both linguistic and pragmatic impairments). For example, Marini, Tavano and Fabbro (2008) showed that the use of a narrative production

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task might highlight the presence of lexical and grammatical disturbances in children with SLI who had scored within normal range on traditional linguistic assessment tests assessing the same abilities.

Accumulating evidence suggests that children with SLI might experience also additional disturbances that are not specifically linguistic. For example, Vugs, Hendriks, Cuperus, and Verhoeven (2014) have recently showed that a large cohort of children with SLI aged 4–5 years scored worse than a group of age-matched peers with typical development on tests assessing executive functions (i.e., inhibition, shifting, emotional control, and planning/organization) and both verbal and visuospatial working memory. These results are not an isolate finding. Indeed, difficulties in the ability to select appropriate responses, inhibit irrelevant ones, plan strategies (e.g., Finneran, Francis, & Leonard, 2009; Henry, Messer, & Nash, 2011) as well as impairments in verbal working memory (vWM) have been frequently observed in children with SLI (Ellis Weismer, Evans, & Hesketh, 1999; Montgomery, 2006) and might affect their linguistic development and functioning. The concept of working memory refers to a set cognitive processes that allow to temporarily store and manipulate limited information (e.g., Cowan, Nugent, Elliott, Ponomarev, & Saults, 2005). According to the phonological storage deficit hypothesis, a difficulty in storing the incoming phonological information might contribute to their linguistic impairments (Archibald & Gathercole, 2007; Bishop, 2006). A reduced vWM capacity may hamper the generation of adequate phonological representations in the mental lexicon, thus leading to difficulties in their recognition when acting as listeners and in their production when involved in language production. These disturbances might negatively affect the child's linguistic development: a difficulty in keeping track of phonological and/or lexical items in short-term memory and eventually process them in working memory might result in slowed vocabulary acquisition (e.g., Gathercole & Baddeley, 1990) and trigger a range of linguistic difficulties (Graf Estes, Evans, & Else-Quest, 2007). Interestingly, the few children with SLI with normal levels of vWM have also better performance on tests assessing linguistic skills and produce longer utteraces (e.g., Botting & Conti-Ramsden, 2001). If present, limitations in vWM might affect the children's efficiency in daily communicative interactions and may lead to the production of shorter utterances. For example, Duinmeijer, de Jong, and Scheper (2012) showed that the performance of a group of children with SLI on the digit span correlated positively with the mean lenght of their utterances (MLU). Furthermore, a deficit in verbal working memory may trigger the selection of inappropriate words that, in turn, might determine qualitatively inferior levels of organization at the text level (macrolinguistic organization).

Unfortunately, the interconnections among these apparently different skills (i.e., working memory, lexical selection, and macrolinguistic organization) cannot be detected by traditional tests assessing production skills in isolation (e.g., naming tests, fluency tasks, etc) but might emerge clearly when applying a multi-level approach to the analysis of language samples obtained on narrative production tasks. For these reasons, the present study focuses on two major issues: (1) the need for a comprehensive assessment of linguistic functions in children with SLI and (2) the opportunity to consider the role potentially played by verbal working memory in linguistic processing in these children with all the implications for appropriate linguistic assessment and remediation. Namely, we analyzed in detail the linguistic and narrative skills of a group of school-age children with SLI and compared their performance with that of a cohort of children with typical development. Importantly, as the levels of verbal working memory might have affected the linguistic performance of the children included in the study, we hypothesized that, when controlling for working memory in the statistical analyses, those group-related differences on language tasks that were heavily biased by vWM capacity would disappear. We also hypothesized that such a comprehensive analysis would allow us to provide a clearer picture of the linguistic disorders that characterize these children and of their potential interconnections at different levels of processing.

2. Methods

2.1. Participants

Sixty-four Italian-speaking participants were included in the study. They formed an experimental and a control group (see Table 1). The experimental group was formed by 32 children with diagnosis of SLI with mixed expressive-receptive disorder (ICD-10 diagnosis: F80.2) aged between 7 and 11.11 years old (mean 8 years and 8 months; standard deviation, SD, 1.6). None of them had mental retardation, psychotic symptoms, brain lesions, auditory difficulties or comorbid dyslexia. The General (verbal and performance) intelligence of SLI participants was assessed by administering the Wechsler scales (Wechsler, 1993). All participants were required to have a Performance Quotient (PIQ) of 85 or above this threshold. The average performance of the SLI participants on Verbal and Performance Intelligence Quotient (IQ) was matched against

Table 1
Means (and standard deviations) showing demographic data of the two groups of participants and their performance on the non-word repetition task.

	SLI ($N = 32$)	TLD ($N = 32$)
Age	8.77 (1.58) – range: 7–11.11	8.61 (1.41) – range: 7–11.11
Education	3.2 (1.6) – range: 1st–6th grade	3.5 (1.3) – range: 1st–6th grade
Sex	$M = 19$	$M = 17$
Non-word repetition*	13.34 (2.21)	14.69 (1.00)

SLI: children with Specific Language Impairment; TLD: children with Typical Language Development.
* Group-related difference on this task was significant ($p < 05$).