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# Auditory processing and speech perception in children with specific language impairment: Relations with oral language and literacy skills

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ABSTRACT

This longitudinal study investigated temporal auditory processing (frequency modulation and between-channel gap detection) and speech perception (speech-in-noise and categorical perception) in three groups of 6 years 3 months to 6 years 8 months-old children attending grade 1: (1) children with specific language impairment (SLI) and literacy delay ($n = 8$), (2) children with SLI and normal literacy ($n = 10$) and (3) typically developing children ($n = 14$). Moreover, the relations between these auditory processing and speech perception skills and oral language and literacy skills in grade 1 and grade 3 were analyzed. The SLI group with literacy delay scored significantly lower than both other groups on speech perception, but not on temporal auditory processing. Both normal reading groups did not differ in terms of speech perception or auditory processing. Speech perception was significantly related to reading and spelling in grades 1 and 3 and had a unique predictive contribution to reading growth in grade 3, even after controlling reading level, phonological ability, auditory processing and oral language skills in grade 1. These findings indicated that speech perception also had a unique direct impact upon reading development and not only through its relation with phonological awareness. Moreover, speech perception seemed to be more associated with the development of literacy skills and less with oral language ability.



## 1. Introduction

SLI is defined as an impairment of spoken language comprehension, production, or both, in the absence of hearing impairment, general developmental delay (i.e., a normal performance IQ), neurological impairment, and autism diagnosis (e.g., Schwartz, 2009). Children with SLI may present deficits in different oral language aspects (phonology, morphology, syntax, semantics and pragmatics), thereby making it a rather heterogeneous group. The etiology of SLI is still hotly debated, ranging from nonlinguistic deficits in auditory perception to high-level deficits in grammar (linguistic deficit) (Joanisse & Seidenberg, 1998). Developmental dyslexia is a disorder characterized by severe reading and spelling difficulties that are persistent and resistant to the usual didactic measures and remedial efforts (Gersons-Wolfensberger & Ruijssenaars, 1997; Vellutino, Fletcher, Snowling, & Scanlon, 2004). Problems with phonology are widely accepted as a cause of dyslexia

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(Snowling, 2000). These phonological problems are possibly rooted in an underlying temporal auditory processing deficit, but the prevailing empirical evidence is mixed (e.g., McArthur & Bishop, 2001). SLI and dyslexia often co-occur; a significant number of children with SLI develops dyslexia (Catts, Adlof, Hogan, & Weismer, 2005; McArthur, Hogben, Edwards, Heath, & Mengler, 2000). One explanation entails that both disorders share a same underlying cause, such as a basic deficit in temporal auditory processing (Tallal, 1980). This auditory deficit is hypothesized to interfere with accurate speech perception and the development of well-defined and robust phonological representations, hence resulting in literacy and language difficulties.

The evidence for an auditory processing deficit in dyslexia was recently reviewed by Hämäläinen, Salminen, and Läppanen (in press). Individuals with dyslexia tend to present problems processing short and rapidly presented acoustic stimuli (e.g., Farmer & Klein, 1995; McArthur & Bishop, 2001). Other studies have also shown impairments processing slowly varying amplitude and frequency modulated signals (e.g., Talcott & Witton, 2002; Witton, Stein, Stoodley, Rosner, & Talcott, 2002) or amplitude rise times (Goswami et al., 2002). These auditory processing problems have been hypothesized to affect the accurate detection of the acoustical changes in speech (i.e., the rapidly varying fine time structure and the slowly varying speech envelope, respectively), which is evidenced by the high prevalence of speech perception problems in individuals with dyslexia (for reviews, see Boets, Ghesquière, van Wieringen, & Wouters, 2007; Vandermosten et al., 2010).

Similar phenomena have been observed in children with SLI. These children too seem to experience problems processing rapid and briefly presented acoustic stimuli (e.g., Tallal, 1999) or durational and amplitude envelope cues (e.g., Corriveau, Pasquini, & Goswami, 2007). Moreover, speech perception problems have also often been reported in children with SLI, such as phonetic features extraction, especially voicing (Ziegler, Pech-Georgel, George, Alario, & Lorenzi, 2005), speech perception in various conditions with and without noise (e.g., Ziegler et al., 2005; Ziegler, Pech-Georgel, George, & Lorenzi, 2011) and categorical perception (e.g., Robertson, Joanisse, Desroches, & Ng, 2009).

However, results of studies measuring auditory processing and speech perception in SLI and/or dyslexia are not unequivocal. A number of studies observed no auditory processing problems in children with SLI and/or dyslexia (e.g., Marshall, Ramus, & van der Lely, 2011) or suggested that the problems would only encompass speech perception and not the perception of non-speech stimuli (Bishop, Adams, Nation, & Rosen, 2005). Moreover, there is a lot of individual variation in the auditory processing abilities of populations with SLI and dyslexia, and impaired performance is usually only observed in a relatively small proportion of them (Bishop & McArthur, 2005; McArthur & Bishop, 2001). Against this background, Rosen (2003) concluded that auditory deficits do not appear to be causally related to language disorders, but only occur in association with them. Overall, a consensus concerning the causal role of auditory processing deficits in SLI and dyslexia has not yet been reached.

Besides the question whether auditory processing and speech perception problems are present in children with SLI and/or dyslexia, and to which extent these exist, one might wonder whether they are more tightly related to oral language impairment (SLI) or to literacy impairment (dyslexia) or to a combination of both. In this regard the study of Gerrits and de Bree (2009) where 3-year old children with SLI as well as a relatively pure group 3-year olds at-risk for dyslexia showed speech perception problems, seems to suggest that speech perception problems are a hallmark of both SLI and dyslexia. A number of studies in school-aged children, however, suggest that auditory temporal processing (Heath, Hogben, & Clark, 1999) and speech perception (Joanisse, Manis, Keating, & Seidenberg, 2000; Robertson et al., 2009) are linked to oral language ability because problems in auditory processing and speech perception were only apparent in children with SLI or with a combination of SLI and dyslexia and not in children with pure dyslexia. Moreover, Robertson et al. (2009) observed a significant relation between receptive language ability and speech perception and only a weak relation between reading ability and speech perception. Similarly, Bishop et al. (2005) observed only a weak relation between speech-in-noise performance and literacy ability in 9–12 year old children with SLI. Additionally, Benasich and Tallal (2002) reported that early deficits in rapid auditory processing in 3-year old children with SLI precede and predict subsequent oral language delays. Quite the opposite, some other studies suggest that auditory processing problems are linked to reading impairment and not to oral language impairment. Indeed, Fraser, Goswami and Conti-Ramsden (2010) observed poorer auditory rise time detection in a dyslexia-only group as well as in a comorbid SLI/dyslexia group, but not in an SLI-only group. These authors also observed that auditory rise time processing was related to reading but not to oral language ability. In a similar vein, McArthur and Bishop (2004) discovered that the SLI-subgroup with deficits in frequency discrimination showed poorer nonword reading. In conclusion, it remains unclear whether and to what extent auditory processing and speech perception problems are associated with language problems, literacy problems or a combination of both.

Another point of discussion is whether auditory and speech perception problems have a direct influence on oral language and/or reading ability (e.g., Boets et al., 2011), or only indirectly through phonology (e.g., Fraser et al., 2010). Also, the relation of auditory processing and speech perception with phonology is not clear. Robertson et al. (2009), for instance, observed no significant correlation between speech perception and phonological awareness, whereas Fraser et al. (2010) observed that auditory rise time processing was uniquely associated with phonological awareness. Results of the study of Joanisse et al. (2000) indicated that not all phonological impairments are caused by speech perception deficits.

Most studies investigated either children with SLI or children with dyslexia, but not a group with the combined disorders. Moreover, there are a lack of studies analyzing the broader range of skills, including auditory processing, speech perception, phonology, literacy and oral language ability, in the same group of participants. The present study aims to fill in this gap by investigating this full range of skills in children with SLI and normal literacy development, in children with comorbid SLI and literacy delay and in matched typically developing controls.