# HEMISPHERIC SPECIALIZATION FOR LANGUAGE IN CHILDREN WITH DIFFERENT TYPES OF SPECIFIC LANGUAGE IMPAIRMENT

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ABSTRACT

The aim of the study was to investigate whether children with Specific Language Impairment (SLI) show reduced left hemisphere specialization for language and, if so, whether it is associated with a deficit in phonological encoding and a specific type of SLI (Mixed Receptive-Expressive, Expressive, Phonological). We adopted two dichotic listening paradigms, which differed in the phonological similarity of the presented words (Fused and Non-Fused dichotic words tests), as well as a phonological working memory test. Participants included 34 pre-school and school age children affected by SLI. On the dichotic tests, as a group the children with SLI showed a reduced pattern of left hemisphere specialization for language compared to age-matched normal children, with significant differences only in the Fused condition. However, the pattern of hemispheric specialization varied depending on the type of SLI, with reduced left hemisphere specialization in the Expressive type and, to a lesser extent, in the Phonological type of SLI, but not in the Receptive-Expressive type. The three subgroups also differed in phonological processing abilities and the incidence of a positive family history for language disorders: the Receptive-Expressive group performed worse on the working memory and dichotic tests and the Expressive and Phonological groups presented high frequency for familial language disorder. These results suggest that different subtypes of SLI are not different manifestations of the same underlying disorder, but represent pathological conditions that have distinct markers both at the behavioral and neurofunctional level.

Key words: specific language impairment, language lateralization, dichotic listening test

## INTRODUCTION

Specific Language Impairment (SLI) is a developmental disorder characterized by a selective failure to make normal progress in language acquisition while other cognitive domains develop normally. According to the DSM-IV criteria (1994), SLI is diagnosed when a child does not follow the normal course of language development in the absence of frank neurological, sensorial or cognitive deficits or psychiatric diseases and in spite of adequate social and educational opportunities for learning. The incidence of such disease ranges from 3-5% to 10-15% (Silva et al., 1987; Aram and Hall, 1989), depending on age and on the criteria of inclusion used in the different studies. However, it is generally agreed that SLI is one of the most common developmental disorders and that children with SLI make heavy demands on both medical and educational services.

The clinical and linguistic profiles of children with SLI have been extensively described (Rapin and Allen, 1988; Rapin et al., 1996; Haynes and Naidoo, 1991; Robinson, 1991; Harel et al., 1996). Different clinical types of the impairment can be identified in which language abilities, expressive only or expressive and receptive, are affected (Rapin et al., 1996; Chilosi et al., 2002). With regard to expressive abilities, phonology and morphosyntax are the linguistic domains most frequently affected: speech productions of most children with SLI are "agrammatic ", with function words or morphemes often omitted (Bortolini et al., 1997; Leonard and Bortolini, 1998; Bortolini and Leonard, 2000). However, the linguistic profile changes with age and development and may be characterized by chronological dissociations within and/or between different components of language; for example, sub-components of grammar may emerge at different times in an anomalous way, or may not emerge at all (Bishop, 1994), at odds with normal development. Regarding receptive abilities, the linguistic domains most frequently affected are lexical and grammatical comprehension.

Based on international classification criteria (DSM-IV, 1994; ICD-10, see Kemali et al., 1992), clinical diagnosis identifies three different types of SLI: Mixed Receptive-Expressive language disorder (RE) if both comprehension and production are impaired; Expressive language disorder (Ex) when only production is impaired; and Phonological disorder (Ph) when the expressive deficit selectively affects the use of the expected speech sounds and phonological rules. The three types of SLI seem to differ also regarding oral language and academic outcome with a more positive prognosis for Ph and Ex than RE children (Cipriani et al., 1998; Chilosi et al., 1998; Snowling et al., 2000). In addition, as recent epidemiological studies suggest, RE, Ex and Ph SLI children not only show different clinical profiles and different outcomes, but also a variable pattern of association with other non language factors, such as the marked predominance of males and the frequency of familial antecedents for language disorders in the Ex and Ph SLI children in comparison with the higher incidence of

neurological abnormalities in the RE children (Chilosi et al., 2002; Picard et al., 1998; Fabbro et al., 2000). Although most researchers studying the causes of SLI have treated the three types of disorders (RE, Ex and Ph) as expression of the same pathology, the above mentioned differences suggest that they may represent distinct clinical conditions with different etiologies.

The pathophysiological mechanisms underlying the different types of SLI are still far from being identified, but some interesting suggestions have come from investigations in the field of cognitive and neurobiological research.

Concerning the possible cognitive deficits responsible for SLI, various hypotheses have been advanced in relation to different theoretical approaches to language acquisition. Following a modularistic view, the core deficit of SLI affects linguistic competence in some specific domains of language processing, and particularly in the components of grammar (Crago and Gopnik, 1994; Rice, 1994). From a functionalistic perspective, instead, SLI is accounted for by a performance deficit affecting information processing capacities in different verbal and non verbal domains (Tallal et al., 1985; Johnston, 1994; Leonard, 1998). Within the latter perspective, the hypothesis of a phonological working memory deficit, affecting the processes at the interface between cognitive and linguistic systems, has recently attracted increasing interest as the possible marker and the most probable heritable cause of SLI (Gathercole and Baddeley, 1990; Adams and Gathercole, 2000; Bishop et al., 1996).

Concerning biological and constitutional factors, several hypotheses have been advanced regarding the etiology of SLI. Recent research based on pedigree analysis and twin studies suggests a significant influence of genes in the etiology of SLI (Hurst et al., 1990; Bishop et al., 1995, 1996; Fisher et al., 1998; Stromswold, 1998; Lai et al., 2001; Bishop, 2002), but how this genetic influence operates is still unknown. One hypothesis is that genetic factors affect prenatal processes of neural migration, which may determine abnormal cerebral organization in children with SLI (Galaburda et al., 1985; Geschwind and Galaburda, 1985). In fact, although SLI children do not typically show evidence of neurological damage or disease, recent brain imaging studies suggest that in some cases SLI is associated with morphological anomalies affecting the language areas of the brain (see Bishop, 2000 for a review). However, it is well known that congenital focal brain damage to the language areas of the brain can lead to a functional cerebral reorganization, so that language is represented elsewhere in the brain and no significant deficits are observed (Chilosi et al., 2001; Brizzolara et al., 2002). The data on children with congenital hemiplegia do not support a 'lesional explanation' in the case of SLI. Thus, it has been hypothesized that SLI is characterized by minor and subtle structural variations of the developing brain which are probably too small and sparse to lead to hemispheric reorganization but sufficient to create a situation in the brain which is not optimal for learning and processing language. Evidence supporting the hypothesis of atypical neural organization of the brain in SLI children comes from two sources: epidemiological studies showing an increased frequency of left-handedness among children with SLI (Bishop, 1990; Robinson, 1991) and neuroimaging studies documenting the presence of both morphological and functional anomalies in cortical language areas.

MRI studies of the posterior cortical areas in SLI suggest reduced or reversed morphological asymmetry of the brain. Gauger et al. (1997) found that SLI children are less likely than controls to have a leftward asymmetry of the planum temporale, which in normal adults and children is usually larger in the left hemisphere. This result, which is in agreement with previous studies (Cohen et al., 1989; Jerningan et al., 1991), has been extended to other cerebral structures. Recently, the pars triangularis of Broca's area, which is known to be a frontal structure important for language function, was found to be smaller in SLI than in control children (Gauger et al., 1997; Clarke and Plante, 1998). It is not yet clear whether the reduced morphological asymmetries of the posterior language areas hold for different types of SLI. Preis et al. (1998) found that SLI with Mixed Receptive-Expressive disorder had a normal left-right anatomical asymmetry of the planum temporale and parietale.

The abnormal structural asymmetry seems to be associated with a reduced left hemisphere functional specialization for language. By measuring cerebral blood flow (SPECT) in phonemic discrimination tasks, it was found that SLI children do not show the expected predominant activation of the left hemisphere (Tzourio et al., 1994; Chiron et al., 1999). According to Tzourio et al.'s study, during receptive language tasks reduced left hemisphere activation characterized the Expressive-Receptive more than the Expressive only children, providing biological support for the existence of different clinical subtypes of SLI. However, functional neuroimaging studies in children have been limited by both ethical (applying methods involving injection of radioactive isotopes purely for research) and methodological factors (noisy procedures, frequent movements, artefacts, etc.). For these reasons, at the moment the evidence of morphofunctional abnormalities is not exhaustive and is limited to small groups of patients.

Of the non-invasive methods, functional hemispheric specialization for language has been traditionally studied with behavioral techniques, such as the dichotic listening paradigm. In this task, two competing verbal stimuli are presented