SPECIAL ISSUE

SPECT FINDINGS IN CHILDREN WITH SPECIFIC LANGUAGE IMPAIRMENT

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Abstract

Findings from ^{99}mTc-HMPAO SPECT measurements at rest in a group of 19 school-age children with specific language impairment (SLI) were compared to a group of 12 children with attention-deficit hyperactivity disorder (ADHD). The regional cerebral blood flow (CBF) distributions were different in the two groups. Children with SLI showed significantly lower CBF values in the right parietal region and in the subcortical region compared to the ADHD group. In addition, the SLI group had symmetric CBF distributions in the left and right temporal regions, whereas the ADHD group showed the usual asymmetry with left-sided hemispheric predominance in the temporal regions. The findings give further evidence for anomalous neurodevelopment with deviant hemispheric lateralization as an important factor in the aetiology of SLI. They also point to the role of subcortical structures in language impairment in childhood. Earlier focus on cortical structures in SLI research needs to be widened to include subcortical regions as well.

Key words: specific language impairment, language disorders, ADHD, SPECT, lateralization, basal ganglia, thalamus

Introduction

Spoken language is one of the greatest achievements in childhood that opens the door to a variety of social and educational experiences. Most children acquire language with surprisingly little effort, and by the age of five, the grammar of the mother tongue is basically mastered (Fromkin, 1998). However, a substantial number of children fail to develop speech and language skills as expected, in most cases for unknown reasons. Such difficulties are estimated to occur in as many as 7% of otherwise normal children (Tomblin et al., 1997). The term specific language impairment (SLI) is applied to children who exhibit a significant deficit in language ability yet display normal hearing, age-appropriate general development and no obvious neurological or psychiatric disorder (Bishop, 1997; Leonard, 1998). Hallmarks of SLI appear to be the late appearance of first words, and the pace of development is slower than in peers. In addition, mastery of syntax and/or semantics is impaired (Bishop, 1997). Children matching this general description have been identified in many countries, representing many different languages (Leonard, 2000). The aetiology, assumed to be multifactorial, is poorly understood.

One main line of research on SLI attempts to identify neurobiological features. Gross brain morphology is usually normal in children with SLI (Rosenberger and Hier, 1980; Harcherik et al., 1985; Nettelbladt et al., 1989; Jernigan et al., 1991). However, by applying morphometric analyses of MRI (magnetic resonance imaging) scans, differences in brain morphology have been demonstrated. Plante reported on atypical perisylvian asymmetries not only in boys with language impairment (Plante et al., 1991), but also in their parents and siblings (Plante, 1991). In addition to perisylvian asymmetry, Jernigan et al. (1991) found asymmetries in the prefrontal and in the parietal regions in children with language- and learning impairment. Other studies have failed to demonstrate similar differences in brain morphology in children with SLI compared to normal children (Gauger et al., 1997; Preis et al., 1998). Reported findings are so far not conclusive.

Functional brain imaging techniques such as single photon emission computed tomography (SPECT) and positron emission tomography (PET) offer another approach to the study of neuronal networks engaged in language processing. Local change in the cerebral blood flow is linearly related to glucose consumption and indicates local neuronal activity (Saper et al., 2000). The correlation between cortical blood flow and metabolic activity has been verified in humans (Raichle et al., 1976, Greenberg et al., 1979). Whereas the early methods for cerebral blood flow measures were two-dimensional, reflecting mainly the blood flow in the cortical mantle, the introduction of three-dimensional techniques such as SPECT and PET enabled visualization of deeper brain structures. Only a few studies of children with language-impairment using SPECT have been published (Lou et al., 1984, 1990; Denays et al., 1989; Tzourio et al., 1994; Valenzuela et al., 1995; Chiron et al., 1999). Lou et al. (1990) reported that children with attention deficit hyperactivity disorder (ADHD) and language impairment had hypoperfusions in the striatal and posterior periventricular regions. By contrast, the findings in children with language impairment only (without

ADHD) were less conspicuous with a lower flow in the left frontotemporal region. Tzourio et al. (1994) found absence of left hemisphere activation during a phonemic discrimination task in children with expressive-receptive language deficits compared to children with only expressive difficulties and to children with ADHD. The authors interpreted the findings as indicating an abnormal lateralization for language in the more severely language-impaired group. A lack of activation in Broca's area but an rCBF increase in the homologous area in the right hemisphere was observed during activation tasks in boys with expressive dysphasia compared to boys with Duchenne muscular dystrophy (Chiron et al., 1999). The authors concluded that the functional specialization of both hemispheres is deficient in children with language impairment.

Although the studies are few, there are indications of both morphological and functional brain differences in children with SLI compared to children with normal language acquisition. An anomalous neurodevelopment with altered hemispheric lateralization and specialization may be a significant factor contributing to inadequate acquisition of language.

Aim of the Study

The main purpose of the study was to investigate whether children with SLI show signs of deviant hemispheric lateralization as indexed by regional differences in the rCBF distribution compared to a group of children with ADHD. If so, this would provide additional support to the hypothesis that anomalous neurodevelopment may play a significant role in the aetiology of SLI. A second purpose was to broaden the scope of the investigation compared to earlier studies by including the subcortical region. A role for subcortical functions in language processing has been proposed among others by Damasio (1983) and Crosson (1985, 1998). It has even been suggested that dysfunction in subcortical structures may be the primary cause in a genetic speech and language disorder and that changes in cortical areas may be secondary to the subcortical dysfunction (Vargha-Khadem et al., 1998).

METHODS

Subjects

The results from ^{99}mTc-HMPAO SPECT measurements at rest in two groups of children with SLI or ADHD were compared:

The SLI group consisted of 19 right-handed children with severe SLI, 11 boys and 8 girls, aged 7;1-15;0 years (mean age 9;7 years). Our criteria (Nettelbladt 1983; Sahlén and Nettelbladt, 1992, 1993) for the diagnosis SLI were failure to acquire normal language at the appropriate age despite adequate hearing and non-verbal intelligence in the absence of major neurological or other physical or psychiatric impairment. The language production is characterised by severe phonological impairment in combination with grammatical impairment. The communicative behaviour is often aberrant.

The children were originally referred to the Department of Logopedics, Phoniatrics and Audiology at Lund University Hospital by other speech and language therapists in Southern Sweden for assessment and treatment of severe language impairments. They all underwent an extensive neuropaediatric examination. One girl who was adopted at the age of three months was born after a normal pregnancy and delivery according to official information. Medical records on antenatal care, delivery and paediatric examination of the newborn were inspected and found to be normal in all the other subjects. A positive family history for speech and language impairment or dyslexia was found in 12 children. Two of them were cousins. Except for a language delay, the children had normal developmental milestones. Because of concern about altered cerebral organization and symmetry in left-handers, only right-handed children were included. Right-handedness was determined from parental interviews and observations of hand preference in three situations: throwing a ball into a basket, using a pair of scissors, and using a pencil. Psychological evaluations with WISC or Griffiths' Mental Developmental Scale indicated general mental development within normal limits. As can be seen in Table I, all the children scored significantly lower on the WISC verbal scales or on the C-scales (hearing and speech) on the Griffiths' Mental Developmental Scale. Neurometabolic screenings, chromosomal analyses, pure tone audiometry, and CT scans or MRT scans of the brains were also all normal. SPECT scans at the time of the medical evaluation did not show any clear abnormality on visual examination. EEG during sleep and wakefulness were also normal except in one girl who had sporadic Rolandic spikes during sleep, without clinical seizures. EEG was subsequently recorded and found normal at the time for injection of the tracer in this patient. The so-called *Phoneme test* (Hellquist, 1984) was used to produce utterances for phonological analysis. The *Ringsted material* (Ege, 1974) was used for grammatical analysis. *Sequential pictures* (Holmberg and Sahlén, 1986) and *Thematic pictures* (Holmberg and Sahlén, 1986) were used for grammatical and interactional analyses. Auditory discrimination was checked using pictures of single objects demanding the production of six minimal pairs: four segmental contrasts, i.e. t/k, t/s, s/sch, s/tj, and two prosodic contrasts, i.e. vowel length (short *vs*. long vowels) and word stress (i.e., initial *vs.* non-initial stress).