

NEURAL DEFICITS IN CHILDREN WITH AUDITORY PROCESSING DISORDER: EVIDENCE FROM FUNCTIONAL MRI

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Abstract

Deficits in acoustic discrimination in children with auditory processing disorder have been observed in behavioral and electrophysiological studies for years. However, the neural correlate of central auditory dysfunction is poorly understood. Atypical activation of brain network implicated in acoustic attention may underlie behavioral problems. The aim of the presented study is to evaluate this hypothesis. 13 children with CAPD, 13 healthy children and 13 adults participated in an fMRI examination. Subjects were studied with fMRI at 3T while discriminating tones differing with intensity, frequency or duration.

The designed paradigm activates brain regions which are known to be implicated in auditory attention. Children with CAPD revealed less spatially extensive activation in: superior frontal gyrus/superior motor area bilaterally, left anterior insula, left parietal lobule.

Differences in brain activity may account for central auditory processing difficulties.

Key words: fMRI • Central Auditory Processing Disorder • attention

Background

Auditory processing disorder (APD) describes listening problems manifested by poor sound localization, auditory discrimination, auditory pattern recognition; temporal aspects of audition; auditory performance in competing acoustic signals [1]. APD may also be accompanied by behavioural difficulties with reading, spelling, expressive and receptive language, phonological processing [1,3,4,8]. Problems associated with APD may result in difficulties with higher order language, learning and communications abnormalities which may hamper school and academic performance [5,6,9]. APD has heterogeneous origins associated with genetic, central and peripheral factors (Moore, 2007). However, due to the scope of the presented study, we will focus on brain mechanisms of APD. Identifying the causes of CAPD is of utmost importance to implement appropriate rehabilitation. Although a number of studies have suggested that CAPD may be associated with an atypical activation of the brain, the neural correlate of central auditory dysfunction is still poorly understood [7].

The aim of the presented study is to investigate the brain correlates associated with central auditory processing disorder (CAPD) within children with the use of functional magnetic resonance (fMRI).

Subject and Methods

Subjects

The experimental group consisted of: 13 children with CAPD (aged: 7–16, mean=11); 13 healthy children (aged: 7–16, mean=11.2); 13 young adults (aged: 20–36; mean=26).

Children with CAPD were recruited in the Institute of Physiology and Pathology of Hearing, where they participated in auditory training developed by the Institute specifically for this group of patients. Children from control group and adults were recruited through advertisement. None of the participants reported history of neurological or psychiatric disorders or head injuries in the past. The children from control groups had no history of dyslexia and other school problems. Each participant provided written informed consent prior to the study.

Central auditory processing examination

The following tests were used to assess central auditory processing: FPT: Frequency Pattern Test; DPT: Duration Pattern Test; GDT: Gap Detection Test; aSPN: Adaptive Speech In Noise. All children with CAPD diagnosis scored below norm and all children from the control group reached results within norm for the certain age.

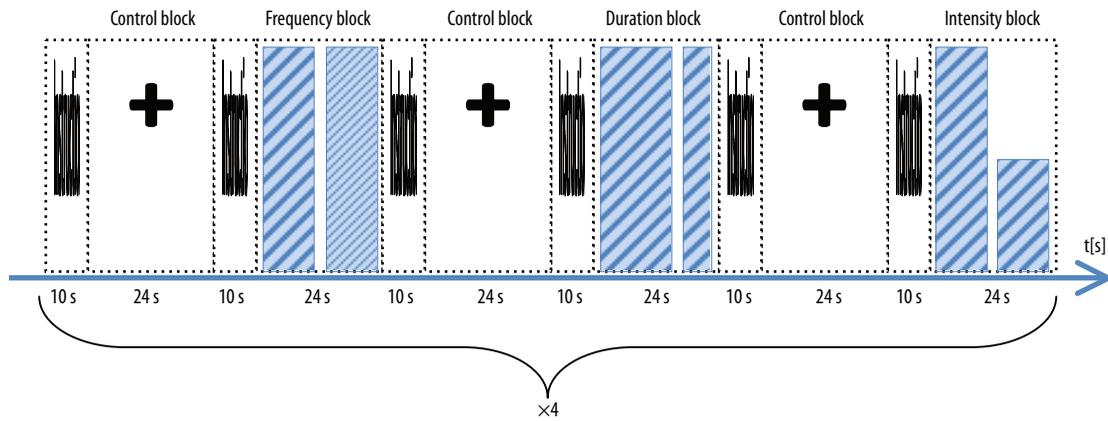


Figure 1. Schema of the study.

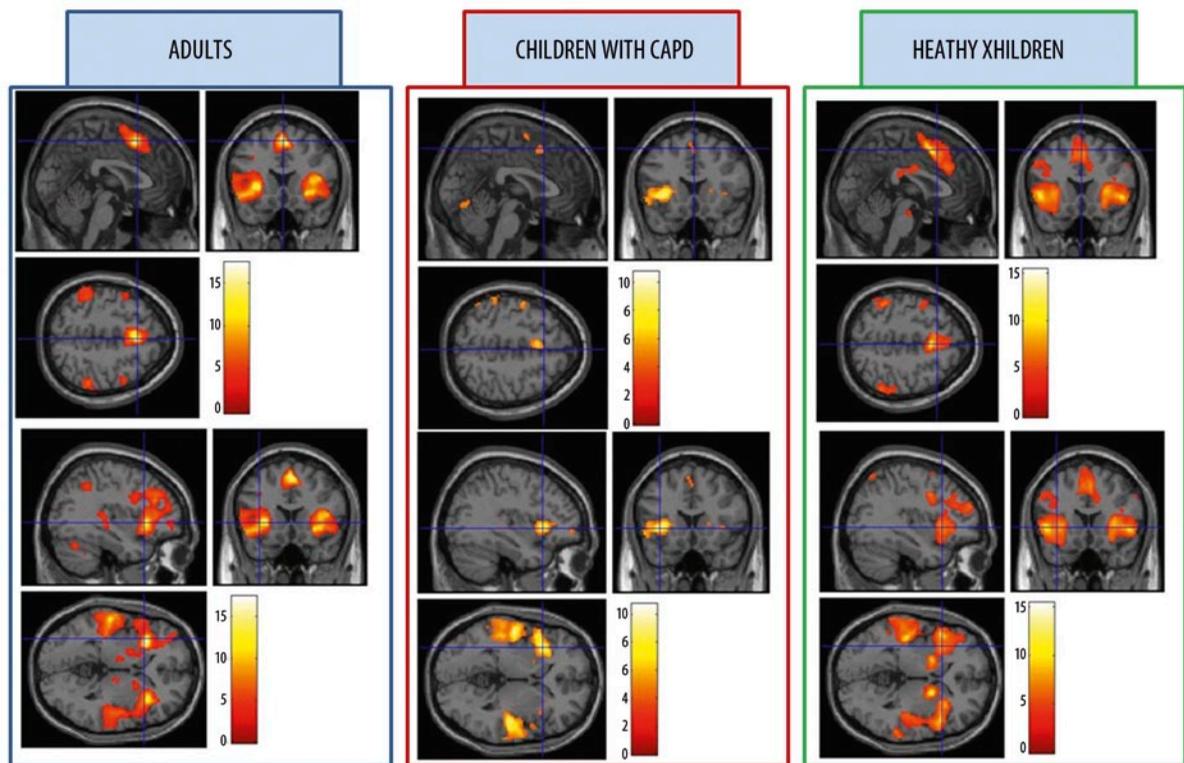


Figure 2. Comparisons of activations between conditions: attentional blocks > control blocks between particular groups.

Functional magnetic resonance protocol and image collection

The fMRI examination was conducted before the therapy began. The study was performed in the 3T MAGNETON TRIO scanner at the Bioimaging Research Center in Institute of Physiology and Pathology of Hearing.

Stimuli

The task consisted of 4 blocks of stimuli: 3 attentional blocks (frequency block, duration block, intensity block) and a control blocks (each lasting 24s). Within the attentional blocks 8 pairs of tones were presented (each lasting 3s), which either differed with frequency, duration or

intensity. Participants were asked to respond by pressing a button with thumb when the same stimulus was repeated twice in a row. The attentional blocks were separated by 24-second control blocks when participants were presented with the fixation cross. Attentional and control blocks were preceded with 10 second instruction in which subjects were reminded of the task (Figure 1).

Data analysis

The fMRI data analysis was performed with SPM8 (www.fil.ion.uci.ac.uk/spm/software/spm8).

Each participant's data were motion-corrected and normalized onto a common brain space (Montreal Neurological

Institute (MNI) template). The data were smoothed using a Gaussian filter (FWHM =8 mm) and high-pass filtered during analysis. For each individual, statistical activation maps were obtained by contrasting all attentional blocks with control blocks. Then, group analysis was carried out to examine brain response to the stimuli within each group of subjects.

Results

Group differences in patterns of brain activation were observed in attentional >control blocks. Adults and children from control group showed robust activations in: superior frontal gyrus/superior motor area, anterior insula bilaterally, inferior parietal cortex bilaterally (Brodmann 40), left middle frontal gyrus, right inferior frontal gyrus, superior frontal sulcus bilaterally. The same contrast within

children with CAPD revealed less spatially extensive activation in: superior frontal gyrus/superior motor area bilaterally, left anterior insula, left parietal lobule (Figure 2).

Conclusions

Children with CAPD tend to display smaller and less extensive activation within brain areas implicated in attention than healthy adults and children. If this trend is still visible within a greater group of subjects, it can suggest that altered brain activity may account for behavioural problems observed within children with CAPD. We also expect that additional comparisons between attentional blocks (frequency vs. duration vs. intensity) may reveal fine-grained differences between groups. This issue needs further investigation.

References:

1. ASHA, (Central) auditory processing disorders: American Speech-Language-Hearing Association, Retrieved June 2005, from <http://www.asha.org/docs/html/TR2005-00043.html>, 2005
2. Bamiou D-E, Musiek FE, Luxon LM: The insula (Island of Reil) and its role in auditory processing. *Brain Research Reviews*, 2003; 42(2): 143-54
3. Chang W: Central Auditory Processing Disorders. Assessment and Remediation. *Neurology*, Elsevier, 2005; 273-86
4. Dawes P: Profile and aetiology of children diagnosed with auditory processing disorder (APD). *International Journal of Pediatric Otorhinolaryngology*, 2008; 72(4): 483-89
5. Dlouha O, Novak A, Vokral J: Central auditory processing disorder (CAPD) in children with specific language impairment (SLI) Central auditory tests. *International Journal of Pediatric Otorhinolaryngology*, 2007; 71(6): 903-7
6. Iliadou V, Bamiou D-E, Kaprinis S et al: Auditory Processing Disorders in children suspected of Learning Disabilities – A need for screening? *International Journal of Pediatric Otorhinolaryngology*, 2009; 73(7): 1029-34
7. Kim M-J, Jeon H-A, Lee K-M et al: Neuroimaging features in a case of developmental central auditory processing disorder. *Journal of the Neurological Sciences*, 2009; 277(1-2): 176-80
8. Miller CA, Wagstaff DA: Behavioral profiles associated with auditory processing disorder and specific language impairment. *Journal of Communication Disorders*, 2011
9. Rosen S, Cohen M, Vanniasegaram I: Auditory and cognitive abilities of children suspected of auditory processing disorder (APD). *International Journal of Pediatric Otorhinolaryngology*, 2010; 74(6): 594-600