Binaural Interaction Component of Middle Latency Response in Children Suspected to Central Auditory Processing Disorder

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Abstracts Binaural processing disorder is an important deficit in children with (C)APD so binaural processing evaluations are crucial. There are subjective and objective tests for assessing binaural processing. Subjective tests require patient attention and active so objective evaluation of binaural processing is important. The aim of present study was investigating binaural interaction component (BIC) of middle latency response (MLR) in children suspected to (C)APD. Sixty 8–12 year-old children suspected to (C)APD and sixty normal children were selected based on inclusion criteria. Both groups were matched in terms of sex (40 boys and 20 girls) and age (9.05 ± 1.25 years old). MLR test (monaural right ear, monaural left ear and binaural) was performed in all the cases and BIC was calculated by subtracting binaural response from summed monaural responses. Independent *t* test showed that latency of Pa and Na (ms), Pa–Na amplitude (μ v), BIC latency (ms) and amplitude (μ v) were significantly different from normal subjects (*p* value ≤ 0.001). Present study showed that MLR and BIC of MLR are clinically available and objective tests that can be used to determining children suspected to (C)APD. These tests might have the potential to separating normal children from children with (C)APD objectively.

Keywords Central auditory processing · Auditory middle latency response · Binaural interaction

Introduction

Central auditory processing disorder (C)APD is defined as a deficit in one or more central auditory processing including auditory localization/lateralization, auditory discrimination, auditory pattern recognition, temporal processing of auditory stimuli, performance deficit in competing signals or when stimuli are degraded [1]. Binaural processing disorder is an important deficit in children with (C)APD so binaural processing evaluations are crucial in these children [2, 3]. Subjective (behavioral) binaural processing tests like localization, speech in noise [4], dichotic stimuli and masking level difference (MLD) tests are integral part of (C)APD test batteries and binaural cues make a base for determining sound direction (ILD and ITD) [5] and understanding speech in noise [6]. Behavioral tests require patient attention and active response [7]. (C)APD has comorbidity with other disorders like attention deficits, learning disorder (LD), autism, and reduced intellectual function and therefore subjective tests can be easily affected by non-auditory factors including reduced attention and lack of cooperation. So there is a need for objective evaluation of binaural processing [1]. The American Speech-Language-Hearing Association (ASHA) Task Force on (Central) Auditory Processing has concluded that electrophysiological measures are useful for diagnosis of (C)APD but has also admitted that further researches are needed to establish clinical utility of auditory evoked potentials [8]. An alternative to behavioral binaural evaluations is binaural interaction component

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(BIC) in auditory evoked potentials. Binaural processing is extent of binaural interaction. If there is no binaural interactions, binaural hearing system is compromised [7]. BIC is the difference between sum of monaural evoked potentials and actual binaural evoked potentials and it is related to directional hearing [9].

The aim of present study was investigating BIC of middle latency response (MLR) in children suspected to (C)APD. BIC of MLR was selected because it has relatively larger amplitude and it can be seen more easily than BIC of ABR. Furthermore, it is not affected by attention unlike BIC of LLR [10] and to our knowledge there is not enough researches about MLR and BIC of MLR in children with (C)APD.

Method

Sixty 8–12 year-old children suspected to (C)APD and sixty normal children were selected based on inclusion criteria. Both groups were matched in terms of sex (40 boys and 20 girls) and age (9.05 ± 1.25 years old). As there is not a gold standard test for (C)APD diagnosis, we selected dichotic digit test (DDT) [11], pitch pattern sequence test (PPS) [12], and monaural selective auditory attention test (mSAAT) [13] based on multiple auditory processing assessment (MAPA) test battery [14, 15]. MAPA study showed that DDT/PPS/mSAAT test battery can provide 90% sensitivity and 100% specificity in (C)APD diagnosis [14, 16]. We used established norms for Persian-version of DDT (free recall), mSAAT-Persian version and PPS test [17].

Inclusion criteria for both groups included normal PTA (auditory threshold less than 20 dBHL in 500–4000 Hz frequency range) in both ears; symmetric hearing thresholds (PTA difference less than 5 dBHL between two ears); normal middle ear function (An tympanogram); 85 or higher Wechsler IQ score, monolingualism (Persian language); no history of ADHD, seizures, behavioral or developmental disorders; not being on any central nervous system medications. All subjects in (C)APD group had poor academic performance and abnormal results in DDT, PPS test and mSAAT. On the other hand subjects in control group had good academic performance and normal results in DDT, PPS test and mSAAT.

MLR test (monaural right ear, monaural left ear and binaural) was performed in all the cases and BIC was calculated by subtracting binaural response from summed monaural responses. MLR recording parameters are as follows: Click stimuli, 70 dBHL, 7.1/s rate, and rarefaction polarity, filter setting of 15–250 Hz. Stimuli were delivered through insert phone. Patients were awake and lied down on bed in an acoustic room. Electrodes were placed on the

right and left mastoids (inverting), on the forehead Fpz (ground), and at the vertex CZ (non-inverting).

Written consent was received from the parents for evaluations. All tests were non-invasive. Patients' information were kept secret. Study was approved by research ethics committee of University of Social Welfare and Rehabilitation Sciences.

Results

Sixty 8–12 year-old children suspected to (C)APD and sixty normal children were selected based on inclusion criteria. Both groups were matched in terms of sex (40 boys and 20 girls) and age (9.05 ± 1.25 years old). Informed consent was obtained from all individual participants and their parents included in the study.

In BIC of MLR there was a positive component that consistently appeared in all the cases between Na and Pa latency regions. That component was marked as BIC and was evaluated.

Latency of Pa and Na (ms), Pa–Na peak-to-peak amplitude (μ V), BIC latency (ms) and BIC amplitude (μ V) in normal children and children suspected to (C)APD is summarized in Table 1.

Independent *t* test showed that latency of Pa and Na (ms), Pa–Na amplitude (μ V), BIC latency (ms) and BIC amplitude (μ V) in children suspected to (C)APD were significantly different from normal children (*p* value ≤ 0.001). In children suspected to (C)APD all latencies were significantly higher and amplitudes were significantly lower than normal values (*p* value ≤ 0.001).

Discussion

In present study MLR and BIC of MLR in children suspected to (C)APD were significantly different from normal children (*p* value ≤ 0.001).

Jerger and Johnson [18] introduced MLR as potentially the single most important auditory-evoked response for identifying (C)APD. MLR abnormalities have been found in learning disabled children and in children with speech or language disabilities [18, 19]. The MLR is also affected in adults with (C)APD [20]. MLR is a clinically available sensitive indicator of central auditory nervous system disorders [21]. Schochat et al. [21] studied thirty children with (C)APD and twenty-two normal children in 8–14 years of age. Four central tests including the pediatric speech intelligibility (PSI) test, speech-in-noise test, staggered spondaic word test (SSW), dichotic digits test and a dichotic nonverbal test were used to identify (C)APD. MLR was recorded in all subjects and peak latencies for Pa

Table 1 latency and amplitude of MLR and BIC MLR

	Na latency		Pa latency		Pa–Na amplitude		BIC latency	BIC amplitude
	Right	Left	Right	Left	Right	Left		
Normal	16.78 (± 0.86)	16.95 (± 1.03)	30.51 (± 1.29)	30.66 (± 1.21)	1.66 (± 0.11)	1.64 (± 0.10)	22.98 (± 0.94)	0.65 (± 0.08)
(C)APD	19.15 (± 0.75)	19.13 (± 0.74)	35.43 (± 1.59)	35.31 (± 1.58)	1.00 (± 0.02)	0.98 (± 0.05)	29.19 (± 0.97)	0.32 (± 0.01)

and Na and peak to peak amplitude for Pa–Na were measured. They found that MLR amplitude was different between these two groups [21]. On the other hand Purdy et al. [22] showed that Na latency and Arehole et al. [23] showed that only Pa latency is longer in children with LD. It was proposed that learning disabled children can also suffer from (C)APD. Purdy et al. [22] showed that teacher ratings of classroom listening and SCAN Competing Words and Staggered Spondaic Word scores were poorer in the LD children. They could not find any amplitude difference between normal children and children with LD. In present study peak latencies and amplitudes were different between children suspected to (C)APD and normal children. This heterogeneity among studies may be due to different inclusion criteria for children with (C)APD and of course different sample size.

BIC has been mostly tested in ABR. We will review BIC findings in children with (C)APD. Gopal and Pierel [4] tested BIC of ABR in 9 children with risk of (C)APD and showed that amplitude of BIC in ABR is significantly different from normal children. They could see BIC (B component) in all test subjects. They used SCAN test for determining (C)APD. Gunnarson and Finitzo [24] showed that BIC in children with history of frequent otitis media (OM) is different from normal children [25]. Children with recurrent OM are at risk of (C)APD [26]. They maintain that B component of BIC in ABR is mostly invisible in children with suspected (C)APD. They showed that using the presence or absence of clearly visible BIC waveforms as an indication of whether a CAPD is present or not, a sensitivity and specificity of 76% could be achieved and they concluded that BIC measurements might be of some diagnostic value in CAPD patients [25]. Pratt et al. [27] showed that BIC is sensitive to little deficits in brainstem.

Conclusion

Present study showed that MLR and BIC of MLR in children with suspected (C)APD were significantly different from normal children. Therefore MLR and its' BIC are clinically available and objective tests that can be used for determining children suspected to (C)APD. MLR as an objective test can be used in children before school age and

may be able to determine potential (C)APD sooner than behavioral central auditory processing tests.

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Compliance with Ethical Standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the institutional research committee (USWR ethic approval) and with the 1964 Helsinki declaration and its later amendments.

Informed Consent Informed consent was obtained from all individual participants and their parents included in the study.

References

1. Strauss DJ, Delb W, Plinkert PK (2004) Analysis and detection of binaural interaction in auditory evoked brainstem responses by time-scale representations. *Comput Biol Med* 34(6):461–477
2. Jerger J et al (1999) Twin study of central auditory processing disorder. *J Am Acad Audiol* 10:521–528
3. Jerger J et al (1991) Central auditory processing disorder: a case study. *J Am Acad Audiol* 2(1):36–54
4. Gopal KV, Pierel K (1999) Binaural interaction component in children at risk for central auditory processing disorders. *Scand Audiol* 28(2):77–84
5. Bernstein LR (2001) Auditory processing of interaural timing information: new insights. *J Neurosci Res* 66(6):1035–1046
6. Ij W et al (2007) Auditory evoked potentials in the detection of interaural intensity differences in children and adults. *Ear Hear* 28(3):320–331
7. Leigh-Paffenroth ED, Roup CM, Noe CM (2011) Behavioral and electrophysiologic binaural processing in persons with symmetric hearing loss. *J Am Acad Audiol* 22(3):181–193
8. American Speech-Language-Hearing Association (2005) (Central) auditory processing disorders. ASHA technical report. <http://www.asha.org/policy/tr2005-00043.html>. Accessed 18 Nov 2016
9. Delb W, Plinkert PK, Strauss DJ (2004) A time–frequency feature extraction scheme for the automated detection of binaural interaction in auditory brainstem responses. *Int J Audiol* 43(2):69–78
10. Goksoy C, Demirtas S, Ungan P (2004) Dynamics of the contralateral white noise-induced enhancement in the guinea pig's middle latency response. *Brain Res* 1017(1–2):61–68
11. Nejati V et al (2016) Persian version of the dichotic digit test for children: design and evaluation of the psychometric properties. *Audit Vestib Res* 25(1):55–62

12. Sanayi R et al (2013) Auditory temporal processing abilities in early Azari-Persian bilinguals. *Iran J Otorhinolaryngol* 25(73):227
13. Aarabi S, Jarollahi F, Sh J (2016) Development and determination of the validity of Persian version of monaural selective auditory attention test in learning disabled children. *Audit Vestib Res* 25(1):49–54
14. Domitz DM, Schow RL (2000) A new CAPD battery—multiple auditory processing assessment factor analysis and comparisons with SCAN. *Am J Audiol* 9(2):101–111
15. Ebadi E et al (2016) Development and evaluation of the Persian version of the multiple auditory processing assessment. *Audit Vestib Res* 25(2):75–81
16. Musiek FE, Chermak GD (2013) Handbook of central auditory processing disorder, volume I: auditory neuroscience and diagnosis, vol 1. Plural Publishing, San Diego
17. Lotfi Y et al (2016) Effects of an auditory lateralization training in children suspected to central auditory processing disorder. *J Audiol Otol* 20(2):102–108
18. Jerger J, Johnson K (1988) Interactions of age, gender, and sensorineural hearing loss on ABR latency. *Ear Hear* 9(4):168–176
19. Miličić D et al (1998) A study of auditory afferent organization in children with dyslalia. *Int J Pediatr Otorhinolaryngol* 46(1):43–56
20. Marvel JB, Jerger JF, Lew HL (1992) Asymmetries in topographic brain maps of auditory-evoked potentials in the elderly. *J Am Acad Audiol* 3:361–368
21. Schochat E et al (2010) Effect of auditory training on the middle latency response in children with (central) auditory processing disorder. *Braz J Med Biol Res* 43(8):777–785
22. Purdy SC, Kelly AS, Davies MG (2002) Auditory brainstem response, middle latency response, and late cortical evoked potentials in children with learning disabilities. *J Am Acad Audiol* 13(7):367–382
23. Arehole S, Augustine LE, Simhadri R (1995) Middle latency response in children with learning disabilities: preliminary findings. *J Commun Disord* 28(1):21–38
24. Gunnarson AD, Finitzo T (1991) Conductive hearing loss during infancy: effects on later auditory brain stem electrophysiology. *J Speech Hear Res* 34(5):1207–1215
25. Delb W et al (2003) The binaural interaction component (BIC) in children with central auditory processing disorders (CAPD): El componente de interacción binaural (BIC) en niños con desórdenes del procesamiento central auditivo (CAPD). *Int J Audiol* 42(7):401–412
26. Laska M et al (1992) Maturation of binaural interaction components in auditory brainstem responses of young guinea pigs with monaural or binaural conductive hearing loss. *Eur Arch Otorhinolaryngol* 249(6):325–328
27. Pratt H et al (1998) Effects of localized pontine lesions on auditory brain-stem evoked potentials and binaural processing in humans. *Electroencephalogr Clin Neurophysiol Evoked Potentials Sect* 108(5):511–520