AUDITORY MIDDLE LATENCY RESPONSE (AMLR) PRE- AND POST- DICHOTIC LISTENING TRAINING USING CAPDOTS™-Integrated

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Introduction

Efficacy data based on behavioural test results have shown the benefits of dichotic listening training[1, 2] in treating binaural integration (auditory divided attention) CAPD deficits. There is also evidence that this training may result in neuroplastic changes of the auditory cortex as measured by the resilience and long-term maintenance of dichotic listening skills following training[3]. However, more direct measures of the auditory cortex using evoked potential testing could provide stronger evidence to support this data. Auditory Middle Latency Response (AMLR) has been used as an objective measure of CAPD.

In normal individuals, the AMLR between the temporal lobes tend to be symmetrical, but in those individuals with auditory cortical lesions, the Pa amplitude was attenuated over the impaired temporal lobe[4]. Moreover, Na-Pa amplitudes have been found to be lower in CAPD children over the left hemisphere for both ipsilateral and contralateral stimulation[5]. Presumably then, any increase in Na-Pa amplitudes should be associated with improvement in auditory processing skills following auditory training.

The Na-Pa amplitudes are also used to calculate Hemisphere Effects (HE) and Ear Effects (EE) as percentage differences between AMLR electrode sites[6]. Large HE and EE are considered an indicator of CAPD[6] and suggest an inter-hemispheric or inter-aural asymmetry in auditory responses. HE and EE measured in percentage difference may indicate a disorder if larger than either 20%[6] or 50%[7]. It may be conversely postulated that smaller HE or EE may be considered an improvement in auditory processing skills following auditory training.

This research project aims to determine whether dichotic listening training using CI can result in measureable improvements on objective, evoked auditory potential testing – the AMLR as measured by absolute Na-Pa amplitude as well as relative Na-Pa amplitudes expressed as HE and EE.

Methods and Materials

CAPDOTS™ - INTEGRATED

CAPDOTS™-Integrated (CI) is an online CAPD training program used for the treatment of binaural integration/ auditory divided attention/dichotic processing deficits. CI utilises stagger time lead-lag paradigm to train dichotic listening skills. The training protocol consists of 20 minutes per day, 5 days per week over 10 – 12 weeks. The training is typically completed at home or at school with an assistant. Remote monitoring and telephone consultations by the clinician are scheduled with the assistant regularly over the training period.

SUBJECTS

S1, a 27yr old male was diagnosed with binaural integration deficit based on a right-ear weakness on monaural low redundancy word lists. He complained of being distracted by sound and difficulty working in an open plan office. S1 completed CI as a home-based program with his wife for a period of 8 weeks. He completed about 80% of the CI program but could not continue as he was leaving for Japan to begin a new job.

S2, a 16yr old home-schooled male student with an adapted learning program was diagnosed with CAPD deficits in binaural integration. His diagnosis was based on classic left-ear deficits on SCAN-3 Competing Words subtest and the Dichotic Digits Test. He completed CI as a home-based program with his mother over period of
10 weeks.

AMLR

The AMLR was recorded on a Bio-Logic Navigator Pro and the equipment settings are tabulated in Table 1. Subjects were instructed to remain quiet but awake. Impedance measures were balanced below 7.0Ω across all electrode sites. AMLR measures were taken before and upon completion of CI.

DATA ANALYIS

Data was analysed using (1) absolute Na-Pa trough to peak amplitudes for Li (left ipsilateral), Lc (left contralateral), Ri (right ipsilateral) and Rc (right contralateral) conditions and (2) percentage differences between the Na-Pa complexes[7] to determine HE (same ear, different hemispheres) and EE (different ear, same hemisphere) as outlined in Table 2.

Table 1: AMLR Recording Parameters

Electrodes	Positive	Non-inverting temporal-parietal C3 (left) and C4 (right)
	Negative	Linked inverted mastoid A1 (left) and A2 (right)
Stimuli	Monaural alternating clicks, 65 or 70dBnHL	
	Rate 9.10/sec, 1000 sweeps	
Recording Parameters	Filters	10 Hz, 1.5kHz
	Time window	99ms

Table 2: Calculation of Hemisphere and Ear Effects

Right hemisphere effect (RHE)	= Ri vs Rc (RC4 vs LC3)
Left hemisphere effect (LHE)	= Li vs Lc (LC3 vs RC4)
Right ear effect (REE)	= Ri vs Lc (RC4 vs LC4)
Left ear effect (LEE)	= Li vs Rc (LC3 vs RC3)

Reference

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Results

SUBJECT 1 (S1)

Comparison of absolute Na-Pa amplitudes pre- and post-CI are presented (Figure 1). There was an increase in amplitude at all electrode sites after CI training, the largest change observed in the Ri condition. The spread over which the Na-Pa amplitudes range was 0.55μV (between smallest and largest amplitude) before CI training. After CI training, the Na-Pa amplitudes fell within a smaller range of 0.34μV suggesting that the Na-Pa amplitudes were more homogenous with each other.

HE and EE were calculated for S1 (Table 3). There is a reduction in RHE (right stimulated), REE and LEE(right and left stimulated). Post-CI HE and EE fell at 20% or below, within the borderline-normal range using the cut-off criterion for normal individuals. There was a small LHE increase for left-stimulated condition. However, the percentage difference was minimal even prior to CI training and as such was not considered abnormal using cut-off criteria.

SUBJECT 2 (S2)

Absolute Na-Pa amplitudes were compared pre- and post- CI. There was an increase in amplitudes, at all electrode sites (Figure 2). The largest increase in amplitude was observed in the Ri condition. The changes and increases in amplitudes in all conditions, Ri, Rc, Li and Lc resulted in better evenness with each other post-CI when compared to pre-CI measures. Pre-CI training, the Na-Pa amplitude range was 0.28μV falling to 0.07μV post-CI.

HE and EE were calculated for S2 (Table 4). Pre-CI measurements reflected smaller HE but larger EE. Post-CI revealed decreases in HE and EE in all conditions. Post-CI HE and EE fall below 10% in all conditions, well within the strictest cut-off criteria of 20%, within the normal range.

Figure 1: Subject1 Na-Pa Pre-CI and Change Post-CI

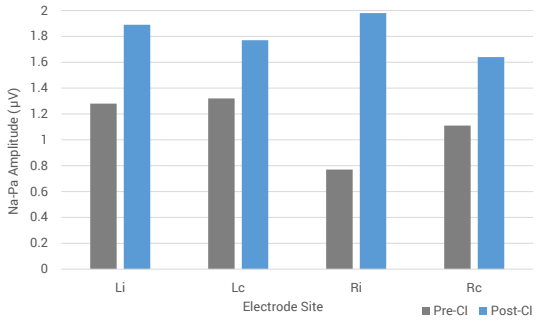

Figure 2: Subject2 Na-Pa Pre-CI and Change Post-CI

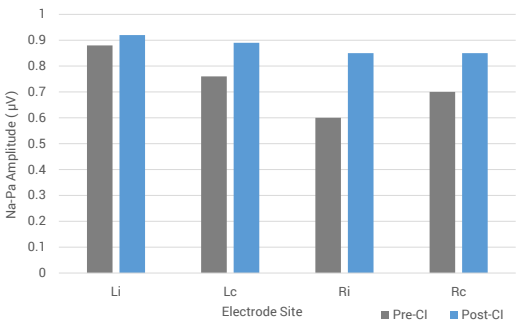

Table 3: Hemisphere and Ear Effects reflected as Percentage Differences

	Hemisphere Effects		Ear Effects	
	RHE	LHE	REE	LEE
Pre-CI	44.16%	3.13%	71.43%	15.32%
Post-CI	20.73%	6.78%	11.86%	15.24%

Table 4: Hemisphere and Ear Effects reflected as Percentage Differences

	Hemisphere Effects		Ear Effects	
	RHE	LHE	REE	LEE
Pre-CI	16.67%	15.79%	26.67%	25.71%
Post-CI	0.00%	3.37%	4.71%	8.24%

Discussion

S1 and S2 were both diagnosed with specific CAPD deficits in binaural integration and received deficit-specific auditory training using CI. The anticipated changes in absolute Na-Pa amplitude were observed at all electrode sites in both subjects. Increased amplitude responses are suggestive of a more robust response of the auditory cortex

The Ri condition generated the smallest Na-Pa amplitude in both subjects pre-CI and also displayed the largest increase post-CI. This implicates the right temporal lobe suggesting its involvment in weak dichotic processing which contrasts with previous findings reported left hemisphere deficits. It should be noted that other studies had not limited their subjects to binaural integration specific deficits which could explain the difference in findings. The attenuated amplitude over the right hemisphere may be analogous to the presence of a right ear deficit on ipsilateral, monaural low redundancy tests in binaural integration deficit.

Increased equality Na-Pa complex across the electrode sites was observed following CI to within a 0.34uV range in S1 and 0.07uV range in S2. The improved evenness of the absolute Na-Pa amplitudes across the 4 electrode sites is suggestive of improved symmetry of responses, an observation seen in the AMLR of normal subjects[4].

Significant reduction in percentage difference HE and EE was observed in 3 out of 4 conditions in S1 and in all 4 conditions in S2. These findings are suggestive of a decreased interhemispheric and interaural asymmetry in auditory function, mimicking the AMLR of normal subjects more closely[5]. S1 presented with a single incidence of increase in left-stimulated hemisphere effect from 3.13% to 6.78%. However, low HE both pre-CI and post-CI are not considered significant and the change may be due to natural variations in AMLR recordings.

Conclusion

Preliminary findings based on these 2 case studies suggest that pre- and post-CI AMLR measurements reveal:

- an increase in absolute Na-Pa amplitudes across all electrode sites
- decreased HE and EE for both right and left stimulation
- improved equality between Na-Pa amplitudes in the Li, Lc, Ri and Rc conditions primarily reflective of large increases in amplitude in the Ri condition.

We can conclude that auditory training using CI on individuals with binaural integration deficits can be observed using AMLR. These findings provide objective evidence that CI facilitates a change in auditory functioning at the neurobiological level and supports the presence of neuroplasticity changes at the cortical level.