Auditory Temporal Processing Ability and the Development of Speech, Language and Reading: Implications for Children with Auditory Neuropathy Spectrum Disorder

By

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DEDICATION

This work dedicated to my mother's spirit

Who raised and supported me through my entire life

She was always my safety net, who brought me to safety when I thought I was falling

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Abstract

Auditory Neuropathy Spectrum Disorder (ANSD) is classified by normal cochlear mechanical function but severely degraded neural synchrony. The auditory system relies on high levels of neural synchrony for processing timing (temporal) cues which are critical for speech perception (particularly in degraded conditions) and normal speech, language and reading development. Unlike most sensorineural hearing losses, speech perception ability in ANSD appears to be correlated with the magnitude of temporal disruption rather than spectral disruption (measured either through the pure tone audiogram or estimated by frequency-specific auditory brainstem responses; ABR). Because ANSD is mostly diagnosed in infants through newborn hearing screening programs, objective tests of temporal processing are needed. The current study focused on the development and evaluation of objective tests of temporal processing for children.

Specifically, the aims of the present study were to:

- identify the likely types of disruptions that occur to speech perception, language and reading abilities in young children with abnormal temporal processing, and the magnitude of disruption that can affect these skills;
- develop and evaluate objective measures of temporal processing in normally hearing adults to provide sensitive measures of assessing different auditory temporal processing abilities:
- evaluate the applicability of these objective measures to normally hearing children (aged 5-12) with normal speech, language and reading abilities and to

normally hearing older adults with poor temporal processing abilities (aged 64–80 years).

This study provides normative data for objective temporal processing measures, which ultimately can be used to evaluate temporal processing abilities in children with ANSD unable to provide behavioural responses. Because of the heterogeneous nature of the disorder and co-morbidity of other medical problems in this population, research in this area is limited. Nonetheless, developing a greater understanding of this problem is critical to improved management of children diagnosed with ANSD and other temporal deficits.

Statement of candidate

I certify that the work in this thesis entitled "Auditory Temporal Processing Ability and the Development of Speech, language and Reading: Implications for Children with Auditory Neuropathy Spectrum Disorder" has not previously been submitted for a degree nor it been submitted as part of requirement for a degree to any other University or institution for a degree other than Macquarie University.

I also certify that the thesis is an original piece of research and it has been written by me. Any help and assistance that I have received in my research work and the preparation of the thesis itself have been appropriately acknowledged.

In addition, I certify that all information sources and literature used are indicated in the thesis. The research presented in this thesis was approved by Macquarie University Ethics review committee, reference number <HE28NOV2008-D06222> <30 January 2009>

Signature

Aseel Al-Meqbel

27 April 2011

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I promise to do my best and to give back even a little portion of that debt and support from my home country Kuwait.

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Thesis organization

This thesis was designed to be a thesis by publication. Four of the six chapters will be submitted to international journals or have formed part of oral presentations at Macquarie University and other national and international conferences during the PhD candidature. This section provides an outline of the thesis.

Chapter 1 is a literature review of two main literatures: a review of a type of hearing disorder known as auditory neuropathy spectrum disorder (ANSD), an auditory temporal processing disorder, and a review of the cortical auditory evoked potentials (CAEPs) as an electrophysiological method to study the auditory system at the cortical level.

Chapter 2 (Paper 1) has been prepared for submission to *Ear and Hearing*. It is a review article that discusses the consequences of auditory temporal processing on speech, language and reading development. The paper draws its conclusions from populations diagnosed with language learning disorders (LLD), such as dyslexia and specific language impairment (SLI), who were also characterized by an auditory temporal processing disruption and where we have assumed that the disruption is more centrally located than in ANSD, which is characterized by disrupted synchrony of the primary afferent nerve as indicated by the poor morphology or absent ABR. In addition, these findings motivated us to question whether ANSD children with auditory temporal processing deficits share similarities in the language and reading disruptions to dyslexic and SLI populations. This particular area has not been fully investigated and little is known regarding language and reading development in school-aged children with ANSD. While it was the initial aim of the current study to address this, the challenges of recruiting individuals with ANSD without additional medical complications or with only milder forms of hearing loss did not permit an in-depth analysis of this disordered population. Instead, this study focuses on the development of a protocol for evaluating speech perception, language and reading abilities in children with ANSD; the development and evaluation of electrophysiological tests of temporal processing in "two normally hearing populations" and young adults and school-aged children (with age-appropriate speech, reading and language abilities) – and the application of these tests of temporal processing in a normally hearing population (older adults) with disordered temporal processing.

Chapter 3 (Paper 2) has been partly presented at the Audiology Australia XIX National Conference 2010, Sydney, Australia and has been prepared for submission to the journal *Clinical Neurophysiology*. The aim of this paper was to study whether cortical encoding of temporal processing ability could be measured objectively (electrophysiologically) in young adults with normal hearing using three temporal processing paradigms: voice-onset-time, speech-in-noise and amplitude-modulation-detection of 16 Hz broadband noise. The N1 latency of the cortical auditory evoked potential (CAEP) was used as a measure of temporal processing.

Chapter 4 (Paper 3) has been prepared for submission to the journal *Clinical Neurophysiology* and will be presented in part at the XXII IERASG Biennial Symposium, 26–30 June, 2011, Moscow, Russia. The aim of this study was to test whether the above three temporal processing paradigms are sensitive to evaluate the disrupted temporal processing in elderly listeners with normal hearing (age-related-temporal processing deficit). The N1 latency was used as a measure of temporal processing, and we compared elderly results with previously evaluated young adult listeners with normal hearing (see Chapter 3).

Chapter 5 (Paper 4) has been prepared for submission to the journal *Clinical Neurophysiology*. The aim of this paper was to determine whether, in normally hearing school-aged children, the N2 latency of the cortical auditory evoked potential (CAEP) could be used as an objective indicator of temporal processing ability where the N1 peak is not present in the cortical waveform.

Chapter 6 presents a summary of all three studies and discusses the implications of the research, possible future research directions and recommended test battery for the evaluation of children with disrupted temporal processing followed by the main references.

Author's contribution to the papers:

- Responsibility for the experimental design and procedure (e.g., develop and generate the stimuli, setting up the equipment, calibration, trouble shooting)
- Conduct of experiments (e.g., participant recruitment and testing)
- All data analysis (statistical analysis, graphing and results interpretation)
- Write-up of all papers.

Co-authors' contributions:

- Initial study design and revisions
- Editorial input
- Advice about interpretation of data.