

**The receptive language and reading abilities of  
students diagnosed with auditory processing  
disorder (APD)**

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## **ETHICS STATEMENT & DECLARATION**

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published by another person except where due reference is made in the text.

The research proposal was approved by the Flinders Clinical Research Ethics Committee (Appendix A). This research was conducted in accordance with the National Health and Medical Research Committee's guidelines on human experimentation. Subject confidentiality was assured. No subject identification data were placed on any computer system.

Signed.....Date...../...../.....

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Secondly, I would like to dedicate this thesis to my wondrous son, James. Whenever I became dispirited, despondent, despairing or just plain defeated he reminded me to 'just finish it'. Such wisdom in one so young.

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## LIST OF ABBREVIATIONS

ADD	Attention deficit disorder
ADHD	Attention deficit hyperactivity disorder
AFG	Auditory Figure Ground subtest
AIT	Auditory inspection task
AM	Amplitude modulation
AP	Auditory processing
APD	Auditory processing disorder
ATOJ	Auditory temporal order judgement
CELF	Clinical Evaluation of Language Fundamentals test
CS	Competing Sentences test
CV, CVC	Consonant-vowel, consonant-vowel-consonant
DRC	Dual Route Cascaded model
DS	Digit Span
FM	Frequency modulation
<i>fMRI</i>	<i>functional</i> Magnetic Resonance Imagery
FUSAPB	Flinders University standard auditory processing battery
GPC	Grapho-phonemic correspondence
IQ	Intellectual Quotient
ISI	Inter-stimulus interval
LI	Language impairment
LSR	Less skilled readers
LTM	Long-term memory
LTWM	Long-term working memory
NAPD	Non-auditory processing disorder
NARA	Neale Analysis of Reading Ability
NWRT	Nonword Repetition Test
OIL	Orthographic input lexicon

PALPA	Psycholinguistic Assessment of Language Processing in Aphasia
PAPI	Processing Auditory and Print Input model
PIB	Phonological input buffer
PIL	Phonological input lexicon
PPS	Pitch Pattern Sequence test; (LT) Left Total, (RT) Right Total
PPVT	Peabody Picture Vocabulary Test
PWM	Phonological working memory
RA	Reading accuracy
RAN	Rapid automatized naming
RAP	Reading Accuracy Profile
RC	Reading comprehension
RCPM	Raven's Coloured Progressive Matrices
RD	Reading disability
$R = D \times C$	Simple view of Reading: Reading = Decoding x Comprehension
RGDT	Random Gap Detection Test
RR	Reading rate
SES	Socio-economic status
SL	Sentence Length test
SLI	Specific language impairment
SR	Sentence Recall test
SRD	Specific reading disability
STM	Short-term memory
SSW	Staggered Spondaic Words test
TOJ	Temporal order judgement
WISC	Wechsler Intelligence Scales for Children
WRMT	Woodcock Reading Mastery Test



## GLOSSARY

**Amplitude modulation (AM) sensitivity** - refers to (detection of) changes to the intensity of sound. Modulation is imposed on a carrier wave, varying the amplitude above and below its unmodulated value, but keeping frequency the same.

**Auditory Processing-** refers to neural processing of the auditory signal; responsible for auditory attention, detection and identification of auditory signals, decoding of auditory input plus storage and retrieval of auditory information.

**Auditory Processing Disorder** - “ a difficulty in the efficiency and effectiveness by which the central nervous system (CNS) utilizes auditory information” (ASHA, 2005)

**Central Executive** - the control system that allocates attention and supervises the elements of working memory. The central executive regulates what information is stored in long-term memory.

**Decoding** – the process by which sections (letters or chunks) of the printed word are converted to the phonological equivalent and blended together to form the word prior to recognition of the whole word.

**Discrepancy Theory** – a method of diagnosing dyslexia based upon a score discrepancy between average or above average IQ scores and reading ability scores greater than 2 standard errors below that predicted by those IQ scores.

**Dyslexia** – dyslexia is a specific learning disability of neurological origin (The International Dyslexia Association, 2002).The criteria for the diagnosis of dyslexia is controversial. Most commonly, reading ability must be significantly below age expectation with evidence of phonological deficits and/or naming deficits. Lack of reading progress is also a strong indicator.

**Encoding-** the process by which the spoken word is translated to its print equivalent.

**Episodic Buffer** – this refers to process within phonological working memory that reactivates prior information, making it available for association with incoming information from the phonological loop or visuo-spatial sketchpad prior to storage in long-term memory.

**Frequency Modulation (FM) Sensitivity-** refers to (detection of) changes in the frequency of sounds. Modulation is imposed on a carrier wave, varying the frequency above and below its unmodulated value while the amplitude remains constant.

**functional Magnetic Resonance Imagery (fMRI)** – a measure of neural activity (oxygen consumption) while the brain is actively engaged in a task or tasks.

**Grapho-Phonemic Correspondence (GPC)** - refers to the letter-sound relationship

**Intelligence Quotient (IQ)** – an IQ score is derived from performance on measures of intellectual ability, standardised against age. The calculation is Mental Age multiplied by 100 divided by Chronological Age to arrive at a score clustered around the mean of 100.

**Inter-Stimulus Interval (ISI)** – the time interval between two stimuli.

**Learning Difficulty** – this definition applies when an individual is having difficulty acquiring literacy or numeracy irrespective of intellectual ability.

**Learning Disability** – this definition applies when an individual has been found to be of average intelligence yet has a specific difficulty with reading (dyslexia), spelling/writing (dysgraphia) or calculation (dyscalculia).

**Less Skilled Readers (LSR)** – refers to readers who are performing below expectation for age but do not fulfil the criteria for dyslexia. Both poor decoding and comprehension are common.

**Long Term Memory (LTM)** – the repository of processed information available for retrieval once activated.

**Matthew effect** - refers to the reciprocal relationship whereby the benefits of reading ensure that good readers become even better readers while less-skilled readers fall further behind. The effect is not simply that ‘the rich get richer’ but rather that readers create a reading environment that promotes greater reading experience e.g. sharing books and stories, requesting books as presents etc.

**Mismatch Negativity** - abnormal brainstem responses linked to susceptibility to noise and also reduced sensitivity to acoustic changes.

**Orthography** – the printed symbols (letters) that represent speech sounds

**Phonological mediation** – the conversion of letter symbols or written words to their corresponding phonology *after* recognition, either silently or spoken aloud. Decoding may or may not be involved *before* recognition (see Decoding).

**Phonological representations** - the neural representations of speech sounds, in isolation (e.g. ‘p’) or as whole words (e.g. ‘parallel’)

**Phonological Awareness** – refers to knowledge regarding the sound structure of the language. Phonological awareness skills include rhyming, syllabification, sound segmentation, blending and manipulation.

**Phonological Working Memory (PWM)** – when auditory short term memory capacity has been exceeded or when verbal information requires manipulation, the information enters the phonological working memory system, where it is processed while presided over by the central executive.

**Prosody** – the suprasegmental features of an utterance e.g. rhythm, stress and intonation. These features convey information about the speaker’s intention and emotional state.

**Rapid naming or Rapid Automated Naming (RAN)** – the rapid (spoken) retrieval of the correct label for an object, picture, letter, symbol or word

**Recoding** – the process by which known letter-sound correspondences are modified to incorporate more complex correspondences e.g. ‘s’ correspondence is modified to incorporate the digraph variation ‘sh’. Often used in relation the complex process of vowel recoding e.g. ‘o’ correspondence must be modified to incorporate ‘oo’, ‘oa’, ‘ou’, ‘ow’ etc.

**Specific Reading Disability (SRD)** – this term is usually applied to determine eligibility for special education funding. SRD is usually diagnosed when reading ability is significantly below (by 2 years or alternatively 2 standard deviations) expectation for age. Persons diagnosed with SRD may be dyslexic or less-skilled readers (LSR).

**(Auditory) Temporal Order Judgement (ATOJ/TOJ)** – refers to the ability to retain the sequence of auditory information and make accurate responses pertaining to that sequence.

### Abstract

This study hypothesized that students with a diagnosed auditory processing disorder (APD) will exhibit significantly greater auditory processing deficits (including phonological working memory), receptive language and reading difficulties compared to a non-APD group (NAPD) in Study One and significantly greater receptive language and reading difficulties compared to a reading-age matched Average reader group in Study Two. A relationship between the degree (severity) of auditory processing deficits and both receptive language and reading ability was also hypothesized. Further, it was hypothesized that the pattern of reading errors exhibited by students with APD will show differences compared to the reading error pattern of the two groups of students without APD. Participants in Study One had already undergone a diagnostic battery of auditory processing assessments. The participants in Study One underwent further assessments of auditory processing including auditory figure-ground, temporal gap detection, pitch perception and auditory sequencing. The Average reader group in Study Two was screened using the Sentence Length test, a screening tool designed to identify children who may be at risk of an auditory processing disorder. For both Study One and Study Two the *CELF:Listening to Paragraphs* subtest and *Peabody Picture Vocabulary Test-3* were administered followed by subtests of the *Woodcock Reading Mastery Tests-Revised* and the *Neale Analysis of Reading Ability-3*. The reading tests cover letter naming, grapheme-phoneme conversion, word identification, word attack and text reading. In Study One, the APD group exhibited significantly poorer phonological working memory (PWM), but not significantly different receptive language or reading abilities than the NAPD

group. Interhemispheric transfer deficits, as demonstrated on dichotic listening tasks, were significantly correlated with PWM performance. PWM ability was significantly correlated with receptive vocabulary, listening comprehension and reading comprehension abilities. The severity of AP deficits was correlated with phonological working memory and receptive vocabulary. The results also suggest a contribution of non-speech auditory processing deficits (frequency discrimination) to PWM and word reading abilities. In Study Two, the APD subgroup exhibited significantly poorer receptive language and reading abilities (based on standard score performance) compared to the reading-age matched Average reader group, matched on raw scores. Again, PWM was significantly correlated with receptive vocabulary, listening comprehension and reading comprehension in the APD subgroup. Reading errors made by the participants with APD were less likely to retain the intended meaning of the text, compared to the NAPD group in Study One. In Study Two, the APD group made as many errors that lost the intended meaning of the text as the significantly younger reading-age matched Average reader group. Analysis of error types in the APD group showed a greater number of whole word substitutions of meaning and word shape and fewer recasting and decoding errors compared to the Average group. The study supports a relationship between auditory processing deficits, phonological working memory and both receptive language and reading abilities.