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**Aspects of the Neuropsychological Development and Assessment of New Zealand  
Children**

A thesis presented in partial fulfilment of the requirements for the degree of

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Kate Sarah Ross-McAlpine

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## Abstract

Typical neuropsychological development in school age children is an under-researched area. There is insufficient research on age effects on performance, relationships between multiple cognitive abilities and between these abilities and academic achievement. In addition to this, there has been no research conducted on neuropsychological assessment practices with children in New Zealand (NZ). This thesis explored patterns of neuropsychological development in typically developing children and provides clarity on the current practices of psychologists conducting neuropsychological assessment with children in NZ.

Study 1 explored the age effects on neuropsychological measures for typically developing children aged 6 to 11 years. Firstly, the scaled scores of NZ children were compared with overseas normative groups and found to be within  $\pm 0.4$  of a standard deviation for all tests except for finger tapping and animal sorting (NEPSY-II). Secondly, age effects were found for all measures of cognitive abilities which is consistent with previous research. Post-hoc findings identified that the most significant improvement occurred between ages 6 and 9 years. The existence of differences between NZ and USA samples, specifically found for animal sorting and finger tapping (NEPSY-II), indicates that New Zealand normative data would be beneficial for some subtests used in neuropsychological assessments.

Study 2 investigated the relationships between cognitive domains and school achievement in typically developing New Zealand children. Correlational analyses found that the majority of the relationships between the cognitive domains were moderate to weak, which is consistent with overseas literature. The findings were mixed in regards to the relationships between neuropsychological ability and school achievement. Most significant relationships with overall school achievement were found in the domains of social perception and working

memory, followed by processing speed, executive functioning and language. While this was congruent with the hypothesis of the study and with the literature, the finding of a non-significant relationship between motor skills and academic achievement was incongruent. Investigating these relationships across age groups revealed that age 6, 10 and 11 years are the periods of middle childhood with the strongest relationships between neuropsychological ability and achievement.

Study 3 was a survey of psychologists who routinely undertook cognitive and neuropsychological assessments with New Zealand children. The WISC-IV was the most commonly used comprehensive measure to assess cognitive and neuropsychological function of New Zealand children and the most commonly used rating scales are the ABAS, CBCL and CCBRS. The results of the survey indicated that test selection appears to be based on familiarity and access. The focus on the diversity of New Zealand culture in the literature was reflected in the finding that the majority of the survey respondents considered it important to obtain normative data for New Zealand children (80.3%).

In summary, these findings provide clarity around patterns of performance of typically developing children and informs the practice of neuropsychological assessment with New Zealand children.

## Acknowledgements

I firstly want to thank the children, parents and psychologists who participated in this research. Without the time and effort that they put into participating, this research would not have been possible. I'd also like to thank all the schools who so warmly welcomed and accommodated us.

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Ehara taku toa i te toa takitahi engari, he toa takitini  
*(Success is not the work of one, but the work of many)*

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## **CHAPTER 1: THESIS INTRODUCTION**

This doctoral research developed from a passion for child developmental neuropsychology and the opportunity to be involved in a larger research project. In this chapter, the development of this thesis topic will be discussed, followed by the overall rationale and argument for the research. The collaborative aspect of this thesis and the role of the writer within the larger research project will be clearly outlined. The final aspect of this chapter will describe the structure and organisation of this thesis.

### **Thesis Topic Development**

In 2012 the School of Psychology at Massey University in Wellington was invited to collaborate with the Centre for Public Health Research (CPHR) on a research project that aimed to investigate the relationship between pesticide exposure and neurodevelopmental effects in New Zealand children. The School of Psychology was asked to provide guidance and support regarding the assessment of neuropsychological functioning and behavioural symptoms.

The opportunity for me to be involved was first discussed in May 2014 for an Honours research project aligning with my strong interest in child neuropsychology. Due to time delays of the larger project, my involvement was postponed until 2015 coinciding with my commencement of the Doctor of Clinical Psychology programme. It began in early 2015 with an extensive review of the literature on neuropsychological development in childhood and neuropsychological assessment of children to determine if independent research could develop from the data being collected in the broader study. Based on this review which is summarised below, it was evident that research in this area was not only warranted but urgently needed. It was at this point that I joined the project.

Initial findings in the literature identified that research on typical neuropsychological development in middle childhood (6 to 12 years old) is neglected (Korkman, 2001; Mous et al., 2017; Rosenqvist, Lahti-nuuttila, Urgesi, Holdnack, & Kemp, 2017). This age range is described as having less pronounced developmental change than other developmental groups such as infancy and adolescence (Bauer, Lukowski, & Pathman, 2011) and therefore has been neglected by neuropsychological research. Specific gaps were identified regarding the limited research on age effects in neuropsychological development in this age group. These age effects have only been investigated using dated samples and until more recently (Rosenqvist et al., 2017), limited cultural groups.

In addition, research on the relationships between multiple neuropsychological abilities has received little research attention. Previous studies are limited by small sample sizes and investigate relationships only between a few abilities. Consideration of multiple neuropsychological abilities is critical in understanding neuropsychological development from a comprehensive perspective. Another key consideration in neuropsychological development is academic achievement. The research on academic achievement and specific cognitive abilities during development neglects to consider this relationship at different ages. More comprehensive research in this area is necessary to determine patterns of typical development, which subsequently allows for identification of atypical performance.

It was evident during this initial literature review, that the understanding of neuropsychological development is dependent on the measures used to assess these abilities. Therefore, consideration of the neuropsychological assessment process and the measures used in this context was required. There is no empirical research identifying commonly used measures during neuropsychological or cognitive assessments with children in New Zealand. Research was

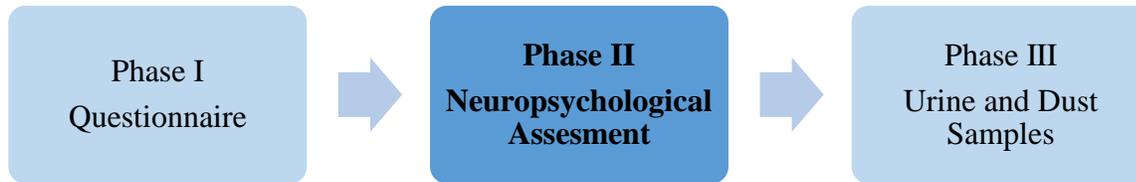
conducted in New Zealand in 2002 on general psychometric use (Dunn & Dugdale, 2002) but there has been no focus on test use with neuropsychological or cognitive assessments with children. Furthermore, consideration of the context of New Zealand within neuropsychological or cognitive assessments with children was limited. Research had found cultural biases with Māori children on a measure of vocabulary (Haitana, Pitama, & Rucklidge, 2010), yet the appropriateness of measures developed outside of New Zealand to assess New Zealand children remained unclear. Furthermore, it was unknown if psychologists who regularly administer these cognitive and neuropsychological assessments were aware of cultural influences on performance or if they made adaptations for use with New Zealand children. The practice of cognitive and neuropsychological assessments with children in New Zealand had received little research attention.

In summary, the thesis topic initially developed from an interest in child neuropsychology, the opportunity for collaboration with the CPHR and the significant gaps in the literature on typical neuropsychological development and assessment of children.

As the collaboration with CPHR provided the context for this thesis, their research project will be summarised below with the contribution and involvement of different researchers clearly outlined.

### **The CPHR Research Project**

The CPHR research project investigating the relationship between pesticide exposure and neurodevelopmental effects in New Zealand children can be summarised into three main phases which are displayed for clarity in Figure 1. The author's involvement was in Phase II.



*Figure 1.* The three phases of CPHR research project

Phase I involved recruitment and completion of the CPHR research questionnaire. The recruitment process began by contacting school principals and sending out invitation letters to parents through the schools to participate in a study on cognition and exposure to pesticides. The CPHR research questionnaire was then completed by the parent or caregiver. The questionnaire was extensive (47 pages) gathering a range of information including demographics, parental work history, parental use of pesticides (frequency, intensity, types), location to farm activities, fruit and vegetable consumption (organic, pre-washed) as well as general health and lifestyle questions. The plan was for the questionnaires to be completed for 900 children; 300 living in urban environment (expected to have lowest risk of exposure), 300 rural (expected to have intermediate risk of exposure) and 300 living on a farm (expected to have highest risk of exposure) in order to assess children from a range of possible pesticide exposure levels.

Phase II involved the neuropsychological testing of 450 children (i.e. half of the children in Phase I) between the ages of 6 and 11 years. The researchers from the School of Psychology were mainly involved with Phase II. The aim of phase II was to assess 150 rural children, 150 urban children and 150 children living on a farm.

Phase III involved the collection of house dust and urine samples from the 450 children included in Phase II to determine the level of exposure to pesticides in the sample. Information gathered in phase I questionnaire was also used to determine the level of pesticide exposure. Due

to the regulations of pesticide use in New Zealand, it was hypothesised that any possible effect of pesticide exposure would be low.

The CPHR project is a long-term project, with the grant approved in 2012 and the main analysis being completed in late 2018. A timeline for the CPHR research project is provided in Table 1 on the following page as a general overview of this long-term project. The author's involvement in the CPHR project (presented in grey shading in Table 1), occurred between February 2015 and December 2016.

As evident in Table 1, the author's involvement included recruitment, neuropsychological testing and scoring and analysis of data collected in Phase II. This included a number of specific tasks which are provided in Table for greater clarity.

Table 1

*General overview of the CPHR research project timeline*

Year	Progress	Location	Phase
2012	Grant Approval	Wellington	

2013	Ethical application accepted	Wellington	
2014	Questionnaire developed	Wellington	I
	Recruitment began	Wellington	I
2015	Recruitment	Wellington	I
	Neuropsychological Testing & Scoring	Wellington	II
	Recruitment	Hawkes Bay	I
	Neuropsychological Testing & Scoring	Hawkes Bay	II
	Collection of Urine and Dust	Wellington	III
2016	Recruitment	Hawkes Bay	I
	Neuropsychological Testing & Scoring	Hawkes Bay	II
	Collection of urine and dust samples	Hawkes Bay	III
	Recruitment	Nelson	I
	Neuropsychological Testing & Scoring	Nelson	II
	Recruitment	Horowhenua	II
	Neuropsychological Testing & Scoring	Horowhenua	II
2017	Collection of urine and dust samples	Nelson	III
	Collection of urine and dust samples	Horowhenua	III

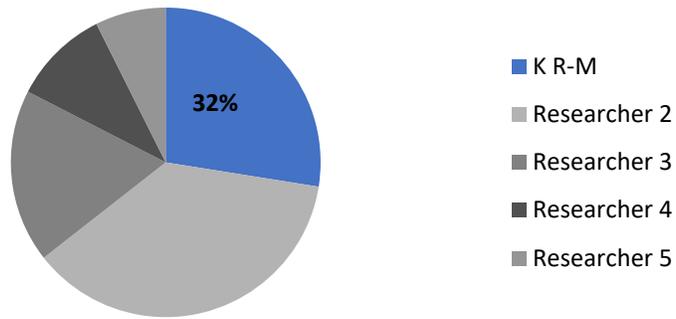
Table 2

*Details of the author's contribution*

Tasks	Location
Neuropsychological test selection	Wellington
Meeting with school principals <sup>a</sup>	Wellington & Hawkes Bay
School assembly presentations <sup>b</sup>	Wellington & Hawkes Bay
Parenting information sessions	Hawkes Bay
Research stall at school fairs <sup>c</sup>	Wellington
Creating testing folders for each child	Wellington
Neuropsychological testing	Wellington & Hawkes Bay & Nelson
Scoring neuropsychological assessments	Wellington
Regular meetings with research group	Wellington

*Note.* <sup>a</sup> = this included initial recruitment meetings as well as meetings to organise Phase II. <sup>b</sup> = See Appendix B: CPHR recruitment presentation. <sup>c</sup> = We attended a number of school fairs with a stall set recruit; we discussed the study with parents and staff and played a “brain game” with children.

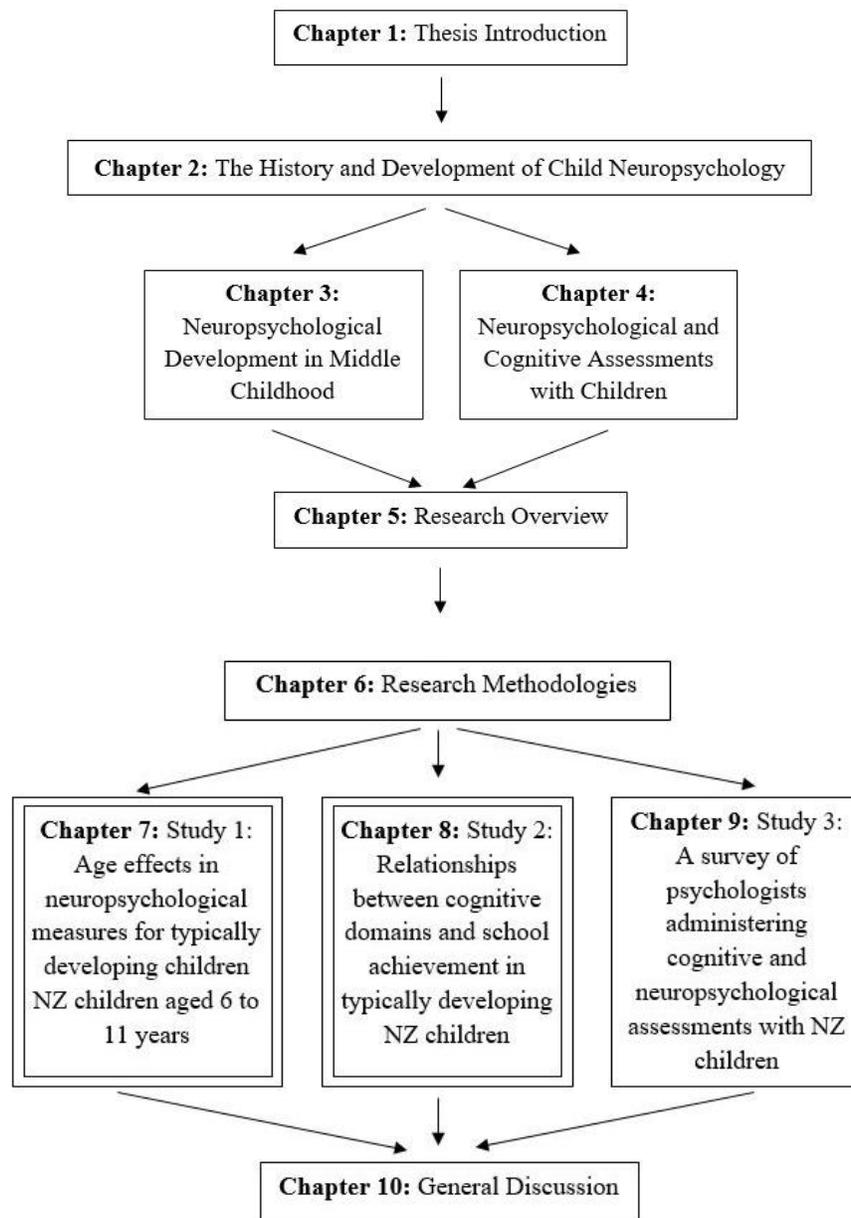
The neuropsychological assessments administered in Phase II were conducted by a number of researchers from the School of Psychology. The proportion of the overall number of neuropsychological assessments the author completed (144) is illustrated in Figure 2 below.



*Figure 2.* Proportion of Neuropsychological Assessments completed by the author

### **Organisation of Thesis**

This thesis is written for publication and includes three research studies presented as manuscripts. Consequently, some content will invariably be repeated as each study is presented as a separate entity. For coherency, the reference list for the thesis, inclusive of the citations within the three studies, is provided at the end. This thesis is organised into ten chapters and the overall structure is presented on the following page in Figure 3.



*Figure 3.* Thesis structure overview by chapters

*Note.* Chapter 7 and Chapter 8 were completed within the collaboration with CPHR as indicated on this figure by the double outline

## **Terminology**

The terms ‘cognitive domains’ and ‘cognitive abilities’ are used interchangeably in this thesis. These cognitive abilities include attention, executive function, processing speed, memory, motor performance, visual perception, language and emotion (Lezak, Howieson, Bigler, & Tranel, 2012; Schoenberg & Scott, 2011). The assessment of these abilities is referred to as ‘cognitive and neuropsychological assessments’. Finally, ‘contemporary neuropsychology’ refers to the current practices of neuropsychology informed by recent literature at the time this thesis is written.

In summary, this chapter provided an introduction to this thesis. As outlined, the development of the thesis topic began with an interest in child neuropsychology, the opportunity to collaborate with a larger research project and identification of significant gaps in the literature. The overall rationale and argument for this thesis was provided by finding limited research in typical neuropsychological development and significant gaps in the literature on neuropsychological assessment practices in New Zealand with children. The collaborative nature of this thesis, the CPHR research project and the role of the writer within this collaboration were outlined. Finally, this chapter explained the structure and organisation of this thesis as written by publication, with three research studies, the first two of which were completed in collaboration with CPHR.

The following three chapters introduce the relevant background literature. The following chapter will discuss the history and development of contemporary neuropsychology, providing the foundation and background of the thesis topic (Chapter 2). This is followed by a review of neuropsychological development in middle childhood (Chapter 3) and an overview of neuropsychological assessment with children (Chapter 4).

## **CHAPTER TWO: THE HISTORY AND DEVELOPMENT OF CHILD NEUROPSYCHOLOGY**

This chapter will provide a brief summary of the history and development of child neuropsychology and the influence different theoretical perspectives have had on contemporary practices. The influence of the interest in measuring intelligence on contemporary psychometric measures will be discussed. This is followed by the influence of the work by Luria on the relationships between cognitive abilities and consideration of an individual's wider social and cultural context. The links between historical influences and contemporary child neuropsychological practices will be identified.

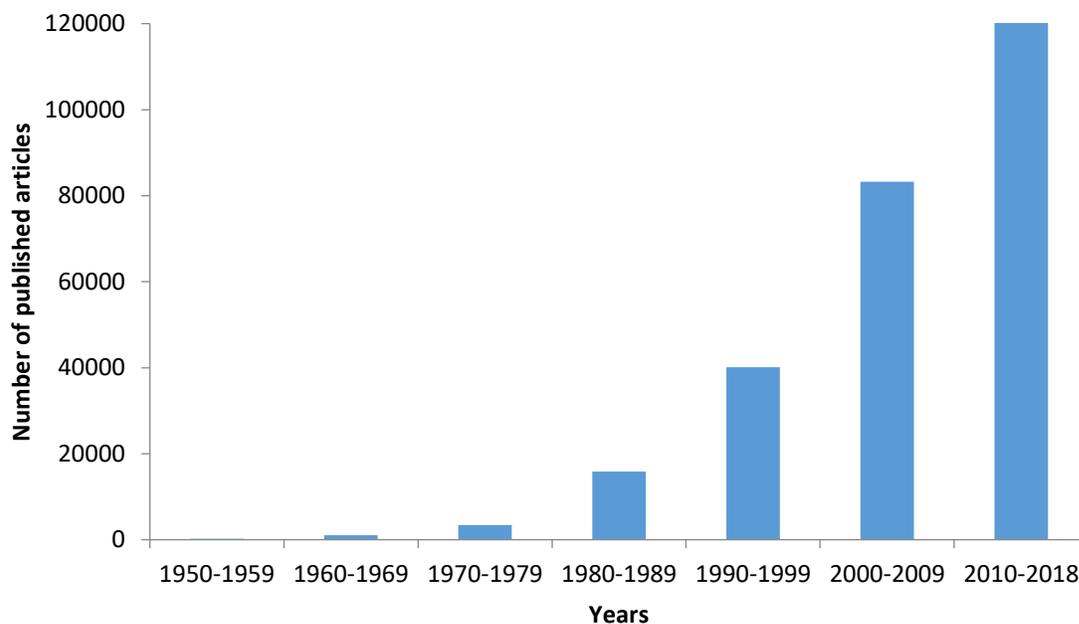
There is a long standing interest in brain injury and dysfunction, with descriptions of brain injuries dating back to 17<sup>th</sup> Century (Darby & Walsh, 2005). Famous cases of specific brain injuries, such as HM and Phineas Gage, sparked unique research endeavours which have contributed significantly to the understanding of brain dysfunction. Interest in specific abilities, have been studied individually throughout history, an example being the study of memory which has been described as, "as old as scientific psychology" (Schneider, 2010, p. 347). It is recognised in the literature that various research perspectives have contributed to the current understanding and practice of neuropsychology (Lezak et al., 2012).

### **Neuropsychology**

The history of neuropsychology is considered to be relatively recent with reviews suggesting the term 'neuropsychology' was first used in 1913 by Sir William Osler (Bruce, 1985). However it wasn't until publications by Donald Hebb in 1949 and Karl Lashley in 1960 that the term became more frequently used (Bruce, 1985), being first used in a textbook by Lezak

in 1976 (Lezak et al., 2012). The influx of post-world war brain injuries was described by Lezak et al. (2012) as providing chief impetus for the development of neuropsychology.

The recent history of neuropsychology is clearly demonstrated when looking at the content of scientific research over recent decades. A literature search of Web of Science, psycINFO and Scopus was completed using the following terms; “neuropsychology” or “neuropsychological assessment”. The significant increase in research over recent decades is depicted in *Figure 1*.



*Figure 1.* Number of published scientific articles on neuropsychology since 1950

### **Child Neuropsychology**

This area of neuropsychology, also referred to in the literature as paediatric (Lajiness-O’Neill, Pawluk, & Jacobson, 2011) or developmental neuropsychology (Glozman, 2013) was

recognised in 1983 as being in its infancy (Rourke, Bakker, Fisk, & Strang, 1983) and now 30 years on, the same is being said (Warner-Rogers, 2013).

Like neuropsychology, it is recognised in the literature that various research perspectives have contributed to child neuropsychology including psychometric research, education, neuroimaging and cognitive psychology (Semrud-Clikeman & Ellison, 2007; Warner-Rogers, 2013). A summary of the main theoretical advances impacting on current child neuropsychological practice over the last century are summarised chronologically in Table 1 on the following page.

Two contributions to contemporary child neuropsychology are discussed below in more depth as they are foundational concepts discussed in recent literature (Baron, 2004a; Glozman, 2013; Warner-Rogers, 2013). First is the focus on intelligence leading to the development of psychometric testing and secondly, the work by Luria on the relationships between cognitive domains and consideration to the wider socio-cultural context.

Table 1

*A brief summary of the contributions to child neuropsychology since 1900*

Theoretical contribution	Contributor	Location	Year
General Intelligence (g)	Spearman	London	1904

“mental tests”	Cattell	United States	
Fluid and Crystallised Intelligence			
Stanford-Binet scale developed – basis of modern IQ test	Binet & Simon	France	1905
Formula developed to compute Intelligence quotient	Wilhelm Stern	Germany	1912
Terman revised Stanford-Binet, included Intelligence Quotient (IQ)	Terman	United States	1916
Stage theory of Cognitive Development	Piaget	Switzerland	1936
Wechsler Scales	Wechsler	United States	1939
Intelligence A and Intelligence B	Hebb	Canada	1941
Biological Intelligence and test battery	Ward Halstead	United States	1947
Nine ability factors	Horn	United States	1965
Three-part theory of the working brain: Three functional units	Luria	Russian	1973
Model of Working Memory	Baddeley & Hitch	Britain	1974
Luria-Nebraska Neuropsychological Test Battery	Golden	United States	1981
Halstead-Reitan Neuropsychological Battery	Reitan & Ward	United States	1985
Hierarchical model of cognitive abilities (three-stratum theory)	Carroll	United States	1993
Cattell-Horn-Carroll (CHC) framework	Cattell, Horn & Carroll	United States	1998
Most recent review of CHC Model	Schneider & McGrew	United States	2012

**Psychometric Testing and Intelligence.** The initial drive, interest and facilitation with measuring intelligence led to the development of various psychometric measures, such as Raven’s Progressive Matrices and the Wechsler scales, which can be used in neuropsychological testing (Lezak et al., 2012). Initial interest in assessing intelligence partially grew from

education, as Binet and Simon, two French researchers who developed the early Binet scale responded to a request to create a measure to determine if a child needed academic support (Baron, 2004a). It is also noted that although the intelligence research field aims to define and assess intelligence, psychometric measures in this area often assess other cognitive functions, such as attention and processing speed (Lezak et al., 2012). Thus, intelligence measures contribute to neuropsychological practice as the psychometrics can be used to assess separate cognitive abilities. A thorough discussion of child neuropsychological assessment measures and the debate on the use of intelligence psychometric measures follows in Chapter 4.

While research on the concept and measurement of intelligence was occurring in the United States, Russian neurologist/ neuropsychologist, Alexander Luria was writing about the way the brain worked.

**Luria's contribution.** Luria has been referred to as the “founding father of neuropsychology” (Akhutina & Pylaeva, 2011, pp. 155) and as “one of the most influential theoreticians in contemporary neuropsychology” (Ardila, 1999, pp. 123). His significant work was on conceptualising how the brain works (Reynolds, Castillo, & Horton, 2008) as three interrelated functional units; 1, the attention-arousal unit (defined as the basic component of intellectual behaviour involving the brain stem, midbrain, thalamus and hypothalamus to allocate resources and effort), 2, the sensory reception / integration unit (which receives, processes and retains information in a three-zone process - auditory from the temporal lobe, tactile from the parietal lobe and visual from the occipital lobe) and 3, the motor unit localised in the frontal lobes, especially the prefrontal cortex which has a number of responsibilities, including regulation of voluntary activity, conscious impulse control and complex human behaviours (such as personality and consciousness) (Luria, 1966, 1973).

Luria's conceptualisation of three functional units working together has had significant impact on how the brain is understood and on contemporary neuropsychology practices. His theory of separate units, with the idea that basic components of attention and effort are required for higher executive functions, is widely accepted in contemporary neuropsychology (Scott, 2011). This conceptualisation recognises lateral inter-relationships as well as a hierarchical structure.

***Cognitive abilities and their inter-relationships.*** There is some argument in the literature about just how many cognitive abilities there are, with Ardila (1999) suggesting from what is known from factor analytic studies and neuropsychological measures, that the likely estimate is between 6 to 10. Domains of functioning can include, but are not limited to; attention and perception, memory, information processing speed, visuospatial abilities, motor function, language and executive function (Ardila, 1999; Lezak et al., 2012; Schoenberg & Scott, 2011). Primarily, the emphasis in neuropsychology is to assess functioning in a variety of domains to understand an individual's strengths and weaknesses (Baron, 2004b).

Although described as separate constructs, it is recognised that the cognitive domains influence each other and work in conjunction. This inter-related concept of cognition has been influenced by the theoretical contributions of Luria and follows the general understanding that the brain operates as an integrated functional system (Naglieri & Otero, 2011). The hierarchical relations between cognitive abilities continues in contemporary neuropsychology practice, as depicted below in a pyramid of skills, (Scott, 2011), see Figure 2 below.

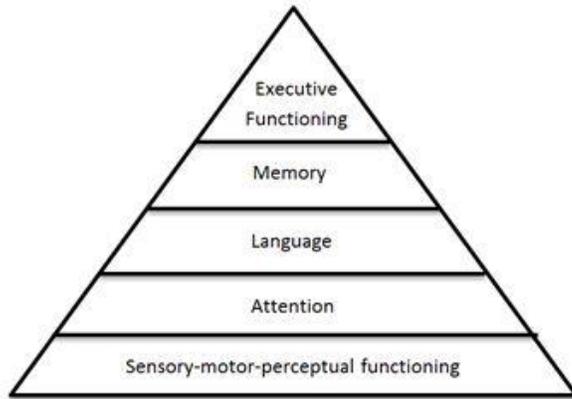


Figure 2. Hierarchy of neuropsychological function (adapted from Scott, 2011)

The overlapping, interrelatedness and hierarchical nature of the cognitive abilities creates a complex picture when seeking to understand the relationships between the cognitive abilities. Understanding the relationships between the cognitive domains, for example how a deficit in one area can impact another, is crucial to understanding an individual's cognitive strengths and weaknesses. The more that is understood about the relationships between cognitive domains in typical developing children, the greater understanding there will be of atypical clinical presentations. Subsequently, this knowledge will contribute to understanding how a deficit in one area will impact on other abilities and thus explain why an individual child may have difficulties. Within a clinical setting, understanding the relationships between cognitive domains, will make it more likely an intervention will be accurate, appropriate and beneficial for that individual. On a theoretical level, understanding the relationships between cognitive domains develops the overall knowledge of typical neuropsychological development. Current literature on the interrelationships between cognitive domains during child development is covered in more depth the following chapter (Chapter 3).

**Socio-cultural Context.** Luria working alongside a colleague Vygotsky also made a significant contribution by identifying the importance of considering the social and cultural

context in child cognitive development (Glozman, 2013). This contribution of Luria's continues in current literature on contemporary child neuropsychology with recommendations that comprehensive neuropsychological assessments should consider *all* aspects of a child's life including social and cultural influences (Glozman, 2013).

A recent review on culture in paediatric neuropsychology called for more research in this area (Olson & Jacobson, 2015). Since that review, literature investigating neuropsychological development has considered culture (e.g., Rosenqvist et al., 2017; Song & Jinyu, 2018) but very few research studies in New Zealand have considered the influence of our unique cultural context (Dudley, 2016). A discussion on neuropsychological assessment in the cultural context of New Zealand can be found in Chapter 4.

Consideration of the wider context in a child's life must include education. Key developmental tasks during childhood include learning to read, write and developing academic competencies. In recent literature, the negative outcomes for children with poor school progress is highlighted as reason to consider academic achievement in neuropsychological assessments (Warner-Rogers, 2013). Additionally, from a neuropsychological perspective, rehabilitation in childhood requires consideration of education and the school environment.

This chapter has summarised the history and development of child neuropsychology. Firstly, the history of neuropsychology and the emerging field of child neuropsychology was discussed. Critical links to contemporary practice were provided from the historical interest in intelligence leading to the development of psychometric measures and from Luria's theoretical contributions to current understanding of the relationships between cognitive domains and practical consideration to the wider socio-cultural context. Overall this chapter provided a

historical background to child neuropsychology as well as identifying the links between historical developments and current practices of child neuropsychology.

The following chapters will discuss the literature on neuropsychological development in middle childhood (Chapter 3) and on cognitive and neuropsychological assessment with children (Chapter 4).

## **CHAPTER THREE: NEUROPSYCHOLOGICAL DEVELOPMENT IN MIDDLE CHILDHOOD**

This chapter presents the literature on neuropsychological development in typically developing children during middle childhood. Firstly, typical neuropsychological development is introduced, followed by an overview of the literature on age effects of neuropsychological abilities. Finally, this chapter provides an exploration of the influences and related variables that require consideration when examining neuropsychological development in middle childhood.

The most note-worthy difference between neuropsychological practice with adults and children concerns development. Childhood is recognised as a period of rapid and multifaceted neuropsychological development (Korkman, 2001; Spritz & Hollister Sandberg, 2010), influenced by a mix of complex environmental and individual attributes. Understanding development during childhood is highly relevant for both educators and clinician's working with children (Spritz & Hollister Sandberg, 2010) and would allow pathways of atypical cognitive development for children in various clinical groups to be established (Hughes & Leekam, 2004). The call for greater understanding of normal brain development continues in neuropsychological literature (Warner-Rogers, 2013).

### **Typical development trajectories and age effects**

Cognitive abilities develop significantly from infancy throughout childhood into adolescence with each child developing at their own pace (Roalf et al., 2014). In 2001 Korkman identified neuropsychological development of children in the school years (5 to 12 years of age) as being an under-researched area. This may have been partly due to suggestions that developmental changes during middle childhood (6 to 11 years) were less pronounced than in infancy or adolescence (Bauer et al., 2011).

The literature on typical developmental trajectories and age effects is reviewed below, first the literature specific to neurocognitive development measures followed by literature focusing on individual cognitive domains.

**Neurocognitive development measures.** Research has explored age effects using the Developmental Neuropsychological Assessment, NEPSY (e.g., Korkman, Kemp, & Kirk, 2001) and its successor the NEPSY-II (e.g., Korkman, Lahti-Nuutti, et al., 2013; Mous et al., 2017; Rosenqvist et al., 2017). The NEPSY was developed to assess neuropsychological development across five cognitive domains (attention and executive functioning, language, memory and learning, sensorimotor and visuospatial processing) during the school years (5-12 years). Korkman, Kemp, & Kirk, (2001) found age effects between the ages 5-12 years, across the subtests. Neurocognitive development was rapid in ages 5 to 8 and more moderate in ages 9 to 12 years. These authors emphasised the need for more research on neurocognitive development in school age children. More recently, Korkman et al., (2013) investigated neurocognitive development with the 2007 NEPSY-II normative data for children age 5 to 16 years. The NEPSY-II was the first neuropsychological measure with children to consider social perception, and therefore the research by Korkman et al., (2013) was the first to include social perception while investigating age effects. Overall, cognitive development during middle childhood was found to fluctuate with more rapid development between 5 to 9 years. Nonlinear development in all subtests was also reported, with each subtest dependent on a combination of cognitive capacities.

More recent research has investigated neuropsychological development with the NEPSY-II in children from USA, Finland and Italy (Rosenqvist et al., 2017). This research confirmed age effects from 5 to 15 years of age and investigated cross-cultural differences in neurocognitive performance from historic normative samples from 2007, 2008 and 2011 (Rosenqvist et al., 2017). They also (Rosenqvist et al., 2017) found that US children

performed lower than European children on visuospatial, constructional and fine-motor abilities and that Italian children performed better than children from Finland and the USA on emotion recognition ability. However, Memory for faces did not differ significantly between countries, indicating robustness across cultures (Rosenqvist et al., 2017).

Research using a validated Dutch adaptation of the NEPSY-II (Mous et al., 2017) investigated effects on age, gender and intelligence with children. Congruent with previous literature they found age effects for most tasks, with the exception of Statue. They attributed this exception to a small sample size. In their sample, girls outperformed boys, except on visuospatial tasks which were most strongly correlated with non-verbal IQ. These authors also commented on the lack of research on neuropsychological development with typically developing school age children.

Aside from the few studies investigating age effects in neuropsychological development with typically developing children, the understanding of age effects in this area is also informed by research investigating the development of specific domains of ability.

### **Development of Neuropsychological Domains**

The literature on neuropsychological development focusing on a single domain, frequently compares typically developing children with children who have neurological, behaviour or psychological difficulties (e.g., Cardoso, Magalhães, & Rezende, 2014; Giofrè & Cornoldi, 2015; Semrud-Clikeman, Fine, & Bledsoe, 2015; Semrud-Clikeman, Walkowiak, Wilkinson, & Minne, 2010). It is important to acknowledge that this research does not primarily focus on age effects during typical neuropsychological development. However, it does contribute to the understanding on neuropsychological development in childhood and is therefore relevant to discuss in this Chapter. This literature on the development of the domains of neuropsychological development is summarised below.

*Attention.* Changes in attentional skills across ages 8 to 17 were investigated by Vakil, Blachstein, Sheinman and Greenstein (2009) using four measures; the Trail Making Test, Digit Cancellation Test and Digit Symbol and Digit Span tests from the WISC-R (Vakil et al., 2009). These authors found that sustained and focused attention improves rapidly up to age 10 and is then more gradual from 10 to 12 years. Research has also found rapid change in divided attention from 7 to 8 years and selected attention from 8 to 9 years (Zebec, Demetriou, & Kotrla-Topi, 2015).

More recent research has identified cultural differences in some attentional functions. Sobeh and Spijkers (2013) investigated multiple facets of attention in Syrian and German children aged between 5 and 12 years of age and as predicted found age-related improvements across all facets of attention. Differences were seen between the two cultures however, with Syrian children having slower and greater variability in their responses and making more errors than German children (Sobeh & Spijkers, 2013). This has implications for cognitive and neuropsychological assessment, which will be discussed in Chapter 4 below. The developmental trajectories for attention and working memory have also been investigated in Japanese school-aged children (Egami et al., 2015) where again, rapid improvements on selective attention tasks were seen between 7 and 10 years of age with gradual improvement in skills from 10 years to 11 years of age (Egami et al., 2015).

In summary it is evident that attentional skills develop at different rates during childhood, with most evidence suggesting rapid development until age 10 and then gradual development from 10 years onwards. Variations are seen between different aspects of attention, for example divided attention is more rapid ages 7 to 8 compared to selective attention which is more rapid ages 8 to 9.

**Memory.** Memory is identified as a fundamental cognitive ability (Bauer & Fivush, 2013), one of the oldest area of cognitive development research (Schneider, 2010), being studied for more than a century (Schneider & Ornstein, 2015). Many different aspects of memory have been the focus of developmental research, including short term, working memory (Cowan, 2014), implicit and episodic memory, learning and long term memory (Lloyd & Miller, 2014; Schneider, 2010).

Looking at the developmental trajectory of the capacity to register new information in 376 children aged 7 to 13 years, Anderson, Northam, Hendy, and Wrennall (2001b) found an improvement with age, with specific spurts at age 8 and age 12.

Working memory is frequently measured using span tasks, which is known to increase during development (Bock, Gallaway, & Hund, 2015). More specifically, research has identified developmental spurts of working memory, one at age 7 and another at 10-11 years of age (Demetriou et al., 2013). Recent research in Japan by Egami et al., (2015) found accuracy for a working memory task was higher in a group of 12 year old children than children 7-9 years of age and associated this with maturation of the hippocampus. Research into age effects of working memory have also used other assessment measures such as n-back tasks with typical age effects in children 7 to 13 years of age (Pelegrina et al., 2015).

A recent article discussing the development of children's memory acknowledged biological and social factors that contribute to developmental change in working memory (Schneider & Ornstein, 2015). This article referred to work done by Cowan (2013) which identified brain growth, increase in knowledge, use of strategies, processing speed and rate of memory trace decay as all contributing to developmental changes in working memory. The authors suggested that the memory strategies do not develop in a straight-forward manner,

with longitudinal research indicating the use of strategies during childhood may present abruptly when techniques are acquired (Schneider & Ornstein, 2015).

A review of the research on the development of memory highlighted the importance of acknowledging that the development of memory does not occur in isolation and urged future research to focus on other contributing factors (Miller, 2014).

***Information Processing Speed.*** Information processing speed, also known as mental speed is a cognitive ability of considerable importance in neuropsychology, as information processing speed is one of the most susceptible cognitive abilities to brain injury (Iverson & Lange, 2011). Processing speed is known to increase substantially in childhood more rapidly than in adolescence (Kail & Ferrer, 2007). More recent research by Demetriou et al., (2013) found unstable change from 4 to 6 years, with change becoming systematic from ages 6 to 7 until early adulthood. Demetriou et al., (2013) also identified two phases of major developmental change in information processing speed; at 7-8 and 11-12 years of age.

***Language.*** The acquisition of language is dependent on the abilities of six dimensions; audition, articulation, words, grammar, communication and literacy (MacWhinney, 2011). In summary the development of these dimensions begins with distinguishing different sounds (audition), followed by producing sound (articulation), then understanding and speaking words (words), using word combinations (grammar), then maintaining conversational skills with others (communication) and finally written language skills (literacy) (MacWhinney, 2011). These dimensions require both expressive and receptive language abilities. From a neuropsychological perspective, language is an important cognitive ability to consider as vocabulary is often used to as an indicator of pre-injury IQ. Language is a multifaceted cognitive ability with significant gender differences identified

(MacWhinney, 2011). Recent research continues to support the findings of female children outperform male children on language tasks (Mous et al., 2017).

***Motor Function.*** Motor function is a broad term used to refer to fine and gross motor tasks. In neuropsychological assessment it is important to ensure that deficits in motor function do not impact on scores in other cognitive tests which require motor skills. Using 10 different motor speed and movement tasks from the Zurich Neuromotor Assessment, Gasser, Rousson, Caflisch, & Jenni, (2010) found the most significant improvements in speed and movement tasks to occur between 5 and 10 years of age, with the dominant side developing faster than non-dominant sides. These authors also found that females outperformed males for sequential tasks, whereas male children outperform females on repetition tasks - however, the effects were small (Gasser, Rousson, Caflisch, & Jenni, 2009).

***Social Perception.*** As noted above, only recently has social perception been acknowledged as an important domain to assess in an evaluation of cognitive and neuropsychological functioning (Korkman, Kirk, & Kemp, 2007). Despite this, social perception is an important ability in childhood and therefore is relevant in this discussion. Social perception plays an important role in social functioning and interactions and has been acknowledged as an underlying foundation for emotional development (Semrud-Clikeman et al., 2015). Social perception involves the ability to understand the feelings, perceptions and intentions of others (Korkman et al., 2007), and includes abilities such as recognising emotion in others (affect recognition) and ability to infer a person's mental states from what they see or do not see (theory of mind). Due to the social functioning deficits associated with Autism Spectrum Disorder (ASD) (American Psychiatric Association, 2013), the assessment of social communication and interaction is recommended in neuropsychological assessments

when considering an ASD diagnosis (National Institute for Health and Care Excellence, 2011).

Previously mentioned research on neurocognitive development by Korkman, Lahti-Nuutti, et al., (2013) was among the first to investigate social perception in neuropsychological research due to the NEPSY-II. These authors concluded that social perception (as measured by theory of mind and affect recognition on the NEPSY-II) reached maturity the earliest of other cognitive abilities, at 11-12 years of age. Consistent with the other cognitive abilities they investigated, rapid development was more apparent during age 5 to 9 years.

***Executive Functioning.*** Executive functioning is undertaken by the frontal regions of the brain and includes skills such as planning, sequencing behaviour, mental flexibility and integrating information from multiple sources (Lezak et al., 2012). These functions allow an individual to engage in purposeful, self-directed and self-serving behaviour (Lezak et al., 2012). The exact definition of executive functioning has been debated in the literature.

Early developmental research argues for three stages in the development of executive function, the first at age 6 with ability to resist distraction, the second at age 10 with impulse control and hypothesis testing and a final stage in early adolescence involving motor sequencing and planning skills (Welsh & Pennington, 1991). Jacobs, Anderson and Harvey (as cited in Anderson, Northam, Hendy, & Wrennall, 2001b) also investigated development in executive function during middle childhood. These authors explained that developmental ‘spurts’ may not be as rigid or categorical as previous research suggested. Anderson (2002) mapped the maturation of executive domains using normative data identifying critical developmental periods for executive functioning as being between 7 and 9 years with maturation of executive domains by 12 years of age. More recent research by (Qian, Shuai,

Chan, Qian, & Wang, 2013) investigated the developmental trajectories of executive function of children and adolescents with Attention Deficit Hyperactivity Disorder (ADHD). These authors found the typically developing participants in their control group, exhibited stability for inhibition, working memory and planning at ages 11-12, while the ability of shifting kept developing until age 13-15.

Research has also investigated the *structure* of executive functioning in children. Longitudinal research by Brydges, Fox, Reid, & Anderson, (2014) indicated that specific executive functions (inhibition, shift, working memory) are indistinguishable until around 9 years of age, but by age of 10-11 years are more separate. This was evident with a one-factor model shifting to a two-factor model over the 2 year testing period. This research provided evidence of the structure and development of executive functions and that cognitive abilities are separate but related.

Since 2001, when Korkman stated that neuropsychological development in school age children was an under-researched area, research on age effects has been conducted with children from USA, Netherlands, Italy and Finland (e.g., Korkman, Lahti-Nuutila, et al., 2013; Mous et al., 2017; Rosenqvist et al., 2017). However, research in this area is still minimal (Mous et al., 2017). When looking critically at previously research, both Korkman, Lahti-Nuutila, et al., (2013) and Rosenqvist et al., (2017) used normative samples from NEPSY-II US data from 2007; data which is now 11 years old. Research with a recent sample of children is necessary to confirm previous findings on age effects in neuropsychological development. Until very recently (Mous et al., 2017; Rosenqvist et al., 2017), research had not been conducted outside of the USA. Currently, it is unknown if these findings on age effects are present beyond USA and European samples of children.

In summary, while there has been research on the development of neuropsychological domains, some of which is summarised above, there has been insufficient research investigating neuropsychological developmental through multiple cognitive abilities with recent samples of typically developing children.

### **Relationships between cognitive domains**

The complex nature of development makes understanding neurocognitive abilities in children, and the processes of their development, challenging (Horton & Horton, 2008). As discussed in the previous chapter, since the work by Luria it has been recognised in the literature that the cognitive domains are related and build on each other even though they have been researched as single constructs. As Lezak et al., (2012) pointed out, in order to have a global perspective on how typical development occurs in middle childhood, it is important to consider the complex relationships between cognitive domains. A summary of some of the recent research in this area is provided below.

An established link has been identified between motor and cognition (Diamond, 2000; van der Fels et al., 2015) during neuropsychological development, with analyses finding moderate correlations between the two (Davis, Pitchford, & Limback, 2011). Motor coordination, executive function and processing speed was investigated in children age 9 to 11 by Luz et al., (2014) who found moderate correlations between executive function and motor coordination tasks. When controlling for processing speed, no effect was found, leading the authors to conclude that processing speed influenced the relationship between motor coordination and executive functioning. This study noted the influence of possible other cognitive abilities (attention) and stated future research could address this.

Bock et al., (2015) investigating the relationship between executive function and theory of mind in children age 7 to 12 years found that cognitive flexibility predicted social

understanding. They also found age improvements, with rapid development age between 7 and 9 years which is consistent with age effects discussed earlier in this chapter.

Language and theory of mind was investigated with 8 and 10 year old children by Grazzani & Ornaghi, (2012) who found that language comprehension played a key role in theory of mind, yet use of language did not. These authors discussed the lack of information on academic performance as a limitation of their study.

Schneider, Lockl and Frenandez (2005) investigated theory of mind, working memory, executive function and language using multiple measures in a longitudinal study with children first tested at 3 years. They found the strongest correlation between language and all other domains; children who had higher language skills, performed better on tasks of theory of mind, working memory and executive function. These authors found no evidence that working memory and executive functioning are the same concept. Furthermore, the longitudinal analysis found that until age 4 the relationship between executive function and theory of mind is explained by comprehension skills.

As highlighted above, there are a number of research articles exploring the relationships between cognitive domains during development in middle childhood (Bock et al., 2015; Davis et al., 2011; Diamond, 2000; Grazzani & Ornaghi, 2012; Luz et al., 2014; Schneider, 2014; van der Fels et al., 2015). This previous research is limited by the number of cognitive domains studied as well as small sample sizes. The relationships between cognitive abilities are an important and relevant consideration in child neuropsychological development and further research is required to explore multiple relationships with a large sample size.

While research is needed to increase understanding the complex relationships between cognitive domains, so too is research on linking the domains to academic achievement (Best, Miller, & Naglieri, 2011; Cameron, Cottone, Murrah, & Grissmer, 2016; Morales, 2015;

Swanson & Alloway, 2012). The following section discusses the literature exploring cognitive abilities and academic achievement.

### **Cognitive ability and school achievement**

Relationships between cognitive ability and school achievement have been considered from several perspectives. Some research has considered links between intelligence (overall cognitive ability) and overall achievement, other research has taken a narrower perspective, either examining relationships between overall cognitive ability and overall academic achievement or specific academic areas (e.g., mathematics, reading, writing) related to specific cognitive domains. These relationships will be presented separately.

As mentioned in the previous chapter, intelligence has been a longstanding focus in psychological research with some stating that intelligence as a concept is seen as conceptually meaningless. However there has been considerable research examining the relationship between intelligence and school achievement which is generally described as bidirectional (Neisser et al., 1996). A recent meta-analysis reported a correlation of .54 (Roth et al., 2015) between intelligence and school grades which is not surprising given the initial purpose of intelligence tests was to predict school performance (Ardila, 1999).

Recent research investigating the relationships between working memory, processing speed, attention and intelligence, found that working memory had a significant and direct effect on general, fluid and crystallized intelligence (Tourva, Spanoudis, & Demetriou, 2016). These authors also found that age had a significant effect on working memory, processing speed, attention, general and fluid intelligence but not on fluid intelligence. It was concluded that of the three cognitive domains they investigated, working memory was the critical component of cognition which formed the basis of intelligence during development.

A limitation of the Tourva et al., (2016) study was the number of participants ( $n = 158$ ) which resulted in only 13 to 17 participants in each age group.

However, the literature is somewhat divided with some research finding certain cognitive abilities, such as working memory, predict school achievement better than intelligence (e.g., Alloway & Alloway, 2009). Research indicates strong correlations between executive function and overall achievement (Lan, Legare, Cameron, Li, & Morrison, 2011; St Clair-Thompson & Gathercole, 2006; Willoughby, Blair, Wirth, & Greenberg, 2012). Specifically, an investigation of the subcomponents of executive functioning and achievement found working memory to be the strongest predictor of achievement in both children from China and the United States of America (Lan, Legare, Cameron, Li, & Morrison, 2011).

Social competence has also been investigated with academic skills. Welsh, Parke, Widaman, & O'Neil (2001) conducted longitudinal research and found academic achievement to directly influence social competence. They found this relationship to be bidirectional, such that social competence influenced academic competence over time as well as academic competence predicting social competence over time. These authors called for more research to investigate mechanism of social and cognitive skills.

Only one study was found that considered *multiple* cognitive abilities and academic achievement, it was with high school children, where the strongest correlations were found between sustained attention and a naming function of language (Morales, 2015). No research appears to have considered multiple neuropsychological abilities and academic achievement in school age children and across different age groups.

Research has investigated cognitive abilities and specific areas of school achievement areas such as mathematics, reading and writing with school age children. Mathematics has

been found to be strongly related to working memory (e.g., Alloway & Passolunghi, 2011; Bull, 2009; Holmes & Adams, 2006; Passolunghi & Lanfranchi, 2012; Raghubar, Barnes, & Hecht, 2010), motor skills (Cameron, Cottone, Murrah, & Grissmer, 2016; Davis et al., 2011; Dinehart & Manfra, 2013; Geertsen et al., 2016; Pitchford, Papini, Outhwaite, & Gulliford, 2016; Son & Meisels, 2006), and processing speed (Passolunghi & Lanfranchi, 2012). Reading achievement has been associated with language skills (Susana, Correia, Miguel, & Pava, 2015), working memory (Pham & Hasson, 2014; Susana et al., 2015) and motor skills (Dinehart & Manfra, 2013; Geertsen et al., 2016; Son & Meisels, 2006). Writing achievement has been associated with working memory (Christopher et al., 2016; Kim & Schatschneider, 2017) and processing speed (Christopher et al., 2016; Cormier & Bulut, 2016; Rindermann, Dimitra, & Thompson, 2011).

The relationship between neuropsychological abilities and achievement is complex with the strength and nature of the relationship differing at different ages during childhood (Alloway & Passolunghi, 2011; Floyd, McGrew, & Evans, 2008). For example, Alloway and Passolunghi (2011) found the relationship between working memory and mathematics differs between 6 and 8-year-old children. This indicates the need for careful consideration of age in typically developing children when exploring achievement and neuropsychological ability in childhood (Mous et al., 2017). Furthermore, it is recognised that culture should be considered for its likely impact on relationships between executive functioning and academic achievement (Song & Jinyu, 2018).

Wider environmental factors have also been considered in respect of the ability and achievement relationship. Research investigating mediating effects on this relationship, found that executive functioning mediates the relationships between socio-economic status and academic achievement (Lawson & Farah, 2017). The school environment has also been investigated in this area with research in Brazil finding significant differences in

neuropsychological performance between adolescents attending private and public schools (Casarin, Wong, Parente, de Salles, & Fonseca, 2012). This finding was independent of socio-economic status which indicated school type was a necessary factor to consider in neuropsychological assessment with adolescents. These considerations of socio-cultural influences on performance can be linked with Luria's consideration of the wider-sociocultural environment as discussed in Chapter 2.

Overall, the research on cognitive ability and academic achievement frequently focuses on single abilities or areas of achievement. There is limited research investigating the relationship between academic achievement and multiple neuropsychological abilities in school aged children. Furthermore, consideration of this relationship at different ages during neuropsychological development is absent in the literature. A thorough investigation of these relationships is needed, which considers multiple neuropsychological abilities as well as how these relationships vary at different ages.

In summary, this chapter reviewed the literature on age effects in neuropsychological development and the complex relationships between cognitive abilities and achievement. It is clear that the typical neuropsychological development of school age children is an under researched area. Given the minimal research that does exist, there are noticeable gaps in the literature. Firstly, the few studies investigating age effects in neuropsychological development have utilised old normative data. Further research is necessary to further clarify the cross-cultural nature of age effects in neuropsychological development outside of USA and Europe with more recent data. Secondly, there is minimal research investigating relationships between multiple neuropsychological abilities and academic achievement. Consideration of this relationship at different ages during neuropsychological development is

also sparse in the literature. Overall, the need for more comprehensive research in typical neuropsychological development in school age children was clearly demonstrated.

The following chapter will discuss neuropsychological and cognitive assessment with children (Chapter 4).

## **CHAPTER FOUR: NEUROPSYCHOLOGICAL AND COGNITIVE ASSESSMENT WITH CHILDREN**

The purpose of neuropsychological assessment will be explored in this chapter, in terms of impairment, ability and achievement. An overview of assessment measures that could be used in a cognitive or neuropsychological assessment with a child will be followed by a discussion on the process of selecting measures. Neuropsychological assessment in the cultural context of Aotearoa, New Zealand will also be explored.

A thorough neuropsychological assessment is composed of a number of components; the presenting problem, background history, qualitative data, quantitative data, formulation and diagnosis, treatment and feedback and evaluation of intervention (Anderson, Northam, Hendy, & Wrennall, 2001a). The quantitative component of a neuropsychological assessment is gathered using psychometric measures which assess cognitive, emotional, social and adaptive behaviours thus providing a snapshot of a child's functioning at one point in time during their cognitive development.

The focus of this chapter is on the quantitative component of a neuropsychological assessment which is summarised in this quote;  
*“Neuropsychological assessment is, in short, a means of measuring in a quantitative standardized fashion the most complex aspects of human behaviour – attention, perception, memory, speech and language, building and drawing, reasoning, problem solving, judgement, planning and emotional processing”* (Lezak et al., 2012, p. 15).

### **Assessment Purpose**

It is essential to determine the purpose of an assessment i.e., whether it is ability (determine the functioning of specific cognitive abilities), achievement (assess knowledge or skill attainment) or impairment (detect impairment or deficits in functioning). As the current focus is on typical development, it is relevant to consider ability and achievement assessments in more depth.

*Assessment of Ability and Achievement.* Distinguishing between ability and achievement is important as often a child may have non-verbal ability that is not reflected in school achievement where the emphasis is on verbal skills or the reverse, they may be achieving at school but not perform as well on tests of non-verbal skills. As education is a dominant part of middle childhood it is important to consider academic performance alongside cognitive development and functioning. Furthermore, there are theoretical and practical implications if children are not achieving at school to their abilities.

The relationships between cognitive abilities and achievement are informed by the correlations reported between standardised psychometric measures. The Wechsler Intelligence Scale for Children (WISC-IV) manual reports correlations with the Wechsler Individual Achievement Test (WIAT-II) with FSIQ stated to be the best predictor of total achievement, followed by the verbal comprehension index (Wechsler, 2003). The Developmental Neuropsychological Assessment, NEPSY-II, also reported correlations with the WIAT-II and found language (Comprehension of Instructions, Phonological Processing) and memory (Narrative Memory, Sentence Repetition) and attention/executive function<sup>1</sup> (Clocks) the strongest correlates with academic achievement (Brooks, Sherman & Strauss, 2009).

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<sup>1</sup> NEPSY-II clusters attention and executive functioning in same domain

## **Psychometrics used in Neuropsychological Assessments with Children**

The number and range of measures that can be used in the cognitive or neuropsychological assessment of children has increased in recent decades and have developed in different ways. Primarily, measures used with adults were adapted for use with children, such as the Halstead-Reitan Neuropsychological Test Battery (Davis & Thompson, 2011) which developed two measures; the Children's Halstead-Reitan Neuropsychological Test Battery (CHRNb; for children 9-14 years of age) and the Reitan-Indiana Test Battery (RINb; for children ages 5-8). However, more recent measures such as the NEPSY and NEPSY-II (Korkman et al., 2007) have been specifically developed for assessment of children. As mentioned in Chapter 2, some psychometric measures used in neuropsychological assessment, developed out of specific theoretical frameworks, such as the Stanford-Binet from intelligence research. Although intelligence measures are not designed specifically for neuropsychological assessment (Baron, 2004a), they are frequently used in child neuropsychological assessments.

Measures used in neuropsychological assessment can be categorised into comprehensive measures, domain specific measures, informant rating scales and measures of achievement. Comprehensive measures include various subtests to gain insight into a range of cognitive functions. Domain specific measures are specific to areas such as attention, memory or executive functioning. Informant or rating scales provide third-party information often from parents or teachers, which is valuable in providing information from multiple sources and environments. For example, if a child is being assessed for Intellectual Disability, it is necessary to have an assessment of adaptive behaviour (American Psychiatric Association, 2013). Depending on the age of the child, self-rating measures are also available. Achievement measures assessing skills or knowledge in specific area, for example mathematics or writing. A summary of measures that could be used in a neuropsychological

assessment are detailed on the following page in these categorises, in alphabetical order in Table 1.

As indicated with asterisks in Table 1, a number of comprehensive measures are used in neuropsychological assessments with children to compute an IQ score. There is some debate within the neuropsychological literature on the use of intelligence tests in child neuropsychological assessment (Ardila, 1999; Baron, 2004a). From one perspective, literature on neuropsychological assessment describes a single intelligence variable as having minimal clinical utility, and the concept of IQ as meaningless and misleading (Lezak et al., 2012). Primarily, the evaluation of a number of cognitive functions, in order to effectively determine cognitive strengths and weaknesses, should be the focus of a neuropsychological assessment (Baron, 2004a). Focusing on a single variable of intelligence has minimal clinical value, unless a referral is requiring a diagnosis of Intellectual Disability, with Lezak et al., (2012) stating that “composite scores of any kind have no place in neuropsychological assessment” (pp. 24). It is also acknowledged that intelligence tests were not designed for neuropsychological assessment (Ardila, 1999). Despite the criticism, their use in child neuropsychological assessment is still recommended in recent literature (e.g., Warner-Rogers, 2013). The advantages of using intelligence test in child neuropsychological assessment has also been discussed by Baron (2004a) and includes standardised samples, familiarity to a wide range of clinicians and psychometric strengths.

Table 1

*Possible measures for use in a neuropsychological assessment of a child*

<b>Measure</b>	<b>Age (years)</b>
<b><i>Comprehensive</i></b>	
Bayley Scales of Infant and Toddler Development- 3rd ed. (Bayley-III)	1 – 3.5
Halstead Neuropsychological Test Battery for Older Children	9 -14
The Neuropsychological Development – 2nd ed. (NEPSY-II)	3 - 16
Kaufman Assessment Battery for Children (KABC-II)	3 - 18
Reitan Indiana Neuropsychological Test Battery	5-8
Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)	12- 89
Luria-Nebraska Neuropsychological Battery for Children (LNNB-C)	8-12
Stanford-Binet V*	2 - 85
Wechsler Intelligence Scale for Children –IV (WISC-V)*	6 - 16
Wechsler Preschool and Primary Scale of Intelligence (WPPSI-IV)*	2 - 6
Woodcock-Johnson III Tests of Cognitive Abilities*	2 - 90+
<b><i>Informant Scales</i></b>	
Adaptive Behavioral Assessment Scale-II (ABAS-II)	Birth - 89
Behavior Assessment Scale for Children (BASC)	2 - 21
Behavior Rating Inventory of Executive Functioning (BRIEF)	5 - 18
Child Behavior Checklist (CBCL)	6 - 18
Conners Continuous Performance Scale – 3 (Conners CPS-3)	8 +
Vineland Adaptive Behaviour Scale – 3 <sup>rd</sup>	Birth - 90
<b><i>Domain Specific</i></b>	
Automated Working Memory Assessment (AWMA)	4 - 22
Bender-Gestalt	3 +
California verbal learning test – children’s version	4 - 16
Children’s Memory Scales (CMS)	5 - 16
Children’s Auditory Verbal Learning Test-2 (C-AVLT-2)	7 - 17
Clinical Evaluation of Language Fundamentals 4 <sup>th</sup> (CELF-4)	5 - 21
Delis Kaplan Executive Functioning Scale (D-KEFS)	8 - 89
Finger Tapping	5- 85
Grip Strength	6 – 85
Peabody Picture Vocabulary Test- 4 <sup>th</sup> (PPVT-4)	2 - 90
Rey-Osterreith Complex Figure for children	6-12
Stroop Colour and Word Test – Children’s Version	4 – 16
Test of Everyday Attention-Children (TEA-Ch)	6 – 16
Wisconsin Card Sorting Test	5 – 89
<b><i>Achievement</i></b>	
Kaufman Test of Everyday Achievement – 3 <sup>rd</sup> Ed	4 – 25
Peabody Individual Achievement Test -Revised	2.5 – 90+
Wechsler Individual Achievement Test – 2 <sup>nd</sup> Ed	5 - 19
Wide Range Achievement Test- 4 (WRAT-4)	5 – 12+

Note. \* Measure computes an IQ score

## **Psychometric Test Selection**

The selection of which psychometric tests to administer in a neuropsychological assessment from the increasing array of psychometrics available, involves a number of considerations. The assessment purpose as well as the referral question can help determine specific concerns relevant to test selection. A broad conceptualisation of test selection identifies the decision is between; flexible test batteries (e.g., NEPSY-II), fixed test batteries (Luria-Nebraska Neuropsychological Test Battery) or by cognitive domains (e.g., DKEFS) (Koziol & Budding, 2011). More specific considerations for selecting a test include psychometric properties (validity and reliability), sensitivity and specificity, parallel forms, time, cost and computerised vs. traditional administration (Lezak et al., 2012). Cultural and ethical considerations are also necessary considerations. The Professional Practice of Psychology in New Zealand (Eatwell & Wilson, 2007) recommends that tests are selected based on content of the measure, psychometric qualities and based on the level the instrument is aimed at.

Previous research in New Zealand on psychometric test selection (not specific to child or neuropsychological assessment) found the most common reasons for choosing a test, were that: a test gathered systemic information, compared well to a criterion, and was credible (Dunn & Dugdale, 2002). Reasons with least support included cost-effectiveness and employer policies (Dunn & Dugdale, 2002). The popularity of measures is likely to be also influenced by factors such as assessor training, experience and competence. The research by Dunn and Dugdale (2002) focused on general psychometric use. These researchers found that the most five commonly used measures (endorsed as being used once a month or more) in general psychometric use were, the Beck Depression Inventory (BDI-II; 27%), Wechsler Adult Intelligence Scale (WAIS-III; 22%), Wechsler Intelligence Scale for Children (WISC-

III; 16%), Ravens Standard Progressive Matrices (SPM; 15%) and Myers-Briggs Type Indicator (MBTI; 14%) (Dunn & Dugdale, 2002).

The second edition of the Professional Practice of Psychology in Aotearoa New Zealand, states the following measures are commonly used for neuropsychological assessment with children; WISC, NEPSY, Wide Range Assessment of Memory and Learning, Californian Learning Test for Children, Test of Everyday Attention for Children, DKEFS, Rey Complex Figure, Conners Ratings and the BRIEF (Ogden, 2007). However, this statement does not appear to be substantiated by empirical research. The research by Dunn and Dugdale (2002) on general psychometric use is 16 years old and needs updating. There has been no research exclusively investigating test use and test selection for cognitive and neuropsychological assessments with children in New Zealand. It is currently unknown what measures are being frequently used and why they are being selected in neuropsychological assessments with children in New Zealand.

An overall assumption in test selection is that the measures selected will be appropriate for the child being assessed. To ensure that this is the case, it is important to consider the normative sample of an assessment measure. The norms or normative results provided for each assessment measure provides a reference point as to what constitutes a typical or normal performance. This provides a standard to directly compare and contrast individual results (Feigin & Barker-Collo, 2007). The normative sample is usually comprised of local people in the geographical area where the tests were developed in (Lezak et al., 2012). An example of this is the NEPSY-II (Korkman et al., 2007), where normative data was gathered in the USA some time ago (Brooks et al., 2009). The children in this normative sample were stratified by age, ethnicity, geographic location and parent education (Brooks, et al, 2009).

As assessment measures are frequently used outside of the geographical and cultural context of where the measures were created, there can be substantial differences between normative groups and population groups being assessed. Research has investigated cultural differences with specific psychometric tools used in the neuropsychological of cognitive assessment of school-aged children. As previously mentioned, Sobeh and Spijkers (2013) acknowledged the cultural variation across the aspects of attention with the Test of Attentional Performance for Children (KITAP) between the children from Syria and Germany. Mulenga, Ahonen and Aro (2001) assessed Zambian children, age 9 and 11 years with the NEPSY, the predecessor for NEPYS-II. These authors compared the results with the age-equivalent US norms. They found the Zambian children performed lower in the domains of language and attention and executive function, but better than the US norms in the visuospatial domain. In addition, these authors acknowledged the cultural variation across the aspects of attention with the Test of Attentional Performance for Children (KITAP) between the children from Syria and Germany. These articles highlight that outcomes on psychometrics measures can vary between different cultural groups.

Given the cultural variation in performance on psychometric measures, it is important to question the confidence with which these measures can be administered within cultures that are different to that of the normative sample, especially in other cultures not yet investigated. Differences between cultures and normative samples may be significant and it is imperative that these are identified in order for assessments to be accurate and appropriate for the individuals being assessed.

### **Cultural context of Aotearoa New Zealand**

Aotearoa New Zealand is a country with a unique cultural context. However, in New Zealand the majority of normative data used in neuropsychological assessments is based on samples from North American (Dudley, 2016; Feigin & Barker-Collo, 2007). A review in

2007 urged the need for accurate normative data for neuropsychological assessments in New Zealand (Feigin & Barker-Collo, 2007). The normative data that has been developed in New Zealand<sup>2</sup> focuses on data across the lifespan and a small number with Māori (Dudley, 2016). The research that has been conducted with New Zealand *children* regarding normative data is summarised below in Table 2.

Table 2

*Normative data on neuropsychological measures with New Zealand (NZ) children*

Measure	<i>n</i>	Age of Sample	Ethnicity	Findings	Authors
WISC-III	60	7-10 years	Pakeha 92.1% Māori 3.4% Other 4.5%	No difference between Australian children and NZ children	Rodriquez, Treacy, Sowerby, & Murphy, (1998)
Stanford Binet 4 <sup>th</sup> edition	60	5-8 years	Pakeha 92.1% Māori 3.4% Other 4.5%	No difference between Australian children and NZ children	Rodriquez et al., (1998)
Rey Complex Figure	840	7-18 years	Pakeha 63.5% Māori 11.9% Pacific Islanders 12% Other 11.6%	Developed normative data for NZ children	Fernando, Chard, Butcher, & McKay (2003)

Administrator awareness of cultural differences whilst completing neuropsychological assessments is critical (Horton, 2008). There has been some research conducted investigating cultural bias in neuropsychological assessments in New Zealand. Haitana, Pitama, & Rucklidge (2010) for example found that the Peabody Picture Vocabulary Test-III (PRVT-111) was largely appropriate with Māori children in mainstream schools but not for children attending Māori-medium schools where results were more indicative of stage of English language development than their overall language ability. These authors suggested

<sup>2</sup> See the Psychological and Neuropsychological Norms for New Zealand data base; <https://cdn.auckland.ac.nz/assets/psych/about/our-research/documents/psychological-and-neuropsychological-norms-for-new-zealand.pdf>

adaptations such as more culturally appropriate target words (e.g., changing Porcupine to Hedgehog) and recommended inclusion of te reo Māori.

As there are limited measures with normative data for New Zealand children, awareness and recognition of cultural influences are critical. It is currently unclear if psychologists who regularly administer these cognitive and neuropsychological assessments are aware of cultural influences on performance, if culture influences their test use, or if they as administrators make adaptations for use with New Zealand children.

In summary, this chapter has explored neuropsychological assessment with children. Firstly, the purpose of assessment was discussed, highlighting the difference and relationship between assessments of ability and achievement. The psychometric assessment measures that can be used to assess children in neuropsychological assessments were reviewed. It was highlighted that the emphasis in neuropsychological assessment is to examine children's functioning across a variety of cognitive domains. The test selection process was also discussed in this chapter. The unique cultural context of New Zealand was discussed and it was acknowledged that currently in New Zealand it is not only unclear just what measures routinely used in neuropsychological assessment, but why they are being selected. This chapter identified that the practice of cognitive and neuropsychological assessments with children in New Zealand has received little research attention.

## **CHAPTER FIVE: RESEARCH OVERVIEW**

This chapter will provide an overview of the research conducted in this thesis. The literature discussed in previous chapters will be summarised and the rationale for the three research studies will be provided. The original research timeline will be detailed, followed by a discussion of the research modifications that were made. Finally, the research aims, questions and hypotheses will be outlined.

### **Literature Summary and Research Rationale**

A discussion on the history and development of neuropsychology acknowledged that child neuropsychology is a very young field. As such, there are significant gaps in the literature in field of neuropsychological development. Primarily, the focus on atypical neuropsychological profiles has resulted in typical neuropsychological development to be under-researched (Mous et al., 2017). As our understanding of atypical development arises from our understanding of typical development, this is problematic. The need for more research into typical neuropsychological development would aid understanding and provide a baseline of expected development. Furthermore, within this area of research, the school age group is neglected in the literature (Korkman, 2001).

As discussed, there has been minimal research exploring age effects in neuropsychological development with typically development children. The research that does exist is limited in cultural contexts and is based on historical data (e.g., Korkman, Lahti-Nuutila, et al., 2013; Mous et al., 2017; Rosenqvist et al., 2017). Research on age effects in neuropsychological development with a recent sample of children would provide further clarification of these findings.

Consideration of culture in child neuropsychology is vital (Olson & Jacobson, 2015). As most research has been conducted in USA and Europe, research is necessary to provide

further clarity regarding the cross-cultural nature of age effects in neuropsychological development. No research on age effects in neuropsychological development has been conducted with New Zealand children.

The complex relationships occurring during neuropsychological development have been acknowledged in the previous chapters. Firstly, the relationships between cognitive abilities are a necessary consideration during development. Previous research in this area is limited by only investigating a few cognitive domains with small sample sizes. Further research is required to explore multiple relationships with a large sample size. The relationships between cognitive abilities are an important and relevant consideration in child neuropsychological development and research of this kind would contribute to understanding typical neuropsychological development and subsequently inform atypical patterns.

Another important relationship during neuropsychological development discussed in the previous three chapters is the relationship between ability and academic achievement. Measures designed to assess intelligence were first designed to detect children who were struggling to meet academic goals. The recent literature on the relationships between neuropsychological development and school achievement has mainly focused on specific abilities and achievement domains, with limited studies in school age children. No research has comprehensively investigated multiple neuropsychological abilities and school achievement during different age groups in neuropsychological development. The need to understanding these complex relationships between neuropsychological abilities and between neuropsychological abilities and achievement is necessary in order to constructed a comprehensive understanding on the global structure of neuropsychological development in typically developing children.

A review of child neuropsychological assessment in Chapter 4 explored current practices in regards to assessment purpose, psychometric assessment measures and the process of test selection. The debate on the use of intelligence psychometrics in neuropsychological assessment was outlined in Chapter 4. This debate is relevant because of the historical context of intelligence psychometrics within neuropsychology (as discussed in Chapter 2), as well as because of the research on neuropsychological development which uses an IQ variable (as discussed in Chapter 3). Given the overall thesis aim and research questions (which are outlined later in this chapter), it was decided that an assessment of IQ was outside the scope and focus of this thesis.

The discussion in Chapter 4 on the context of Aotearoa New Zealand highlighted that the practices of cognitive and neuropsychological assessments with New Zealand children has not been previously investigated. It is not clear what measures are currently being used, if adaptations are being made in administration for culture or what the opinions and experiences are of the clinicians conducting the assessments. It was also discussed that New Zealand has limited normative data for neuropsychological assessments with children and it is currently unclear if New Zealand children are performing comparably to the overseas normative groups. In order to have a thorough understanding on the impact of culture and better accuracy in assessments, a comparison of New Zealand children with overseas norms and exploring current assessment practices is necessary.

In summary, the rationale for this thesis is driven by significant gaps in the literature on age effects in neuropsychological development in school age children, the relationships between neuropsychological abilities and achievement, and the practice of cognitive and neuropsychological assessments with New Zealand children. These gaps in the literature are addressed in the three studies of this thesis; Study 1: “Age effects in neuropsychological

measures for typically developing children aged 6 to 11 years”, Study 2: “Relationships between neuropsychological abilities and school achievement in New Zealand children” and Study 3: “A survey of psychologists administering cognitive and neuropsychological assessment with New Zealand children”.

### **Research Timeline**

The original plan was to conduct a research survey of psychometric test use in New Zealand which would inform the test selection for the additional studies on neuropsychological development. However, due to the reality of collaborating with a larger research project, selection of psychometric measures for the larger research project was required before the research survey could be completed. However, during the test selection process for the neuropsychological assessments, the original idea for the survey was reinforced and developed further. The discussion with the researchers during test selection, which is described in the following chapter, reinforced the gaps identified in the literature and provided further rationale for the value of a survey of this nature.

### **Aims, research questions and hypotheses**

The overall aim of the thesis is to explore under-researched patterns of typical neuropsychological development and determine current practices of neuropsychological assessments in New Zealand. The research questions and hypotheses are presented below.

*Figure* on the following page outlines which research questions are addressed in each research study and in which Chapter they can be found.

Study 1	Research Question 1	Chapter 7
	Research Question 2	
Study 2	Research Question 3	Chapter 8
	Research Question 4	
Study 3	Research Question 5	Chapter 9
	Research Question 6	

*Figure 1.*  
Thesis research questions and associated research study and Chapter

**Research Question 1.** To what extent do cognitive scores of New Zealand children correspond to cognitive scores from the US norms? Based on New Zealand cross-cultural literature in neuropsychology (Dudley, 2016; Dudley, Faleafa, & Yong, 2016) it was hypothesised that there would be differences between New Zealand children and overseas norms. Based on the recent research by Rosenqvist et al., (2017) it was hypothesised our sample of NZ children would perform better on NEPSY-II subtests than USA norms.

**Research Question 2.** What are the age effects in neuropsychological development through middle childhood ages 6 to 11 years? It was expected that the results would show age effects for all measures of neuropsychological ability.

**Research Question 3.** What are the relationships between neuropsychological abilities in school age children? It was expected that there would be some variation in the strengths of relationships between neuropsychological abilities, however the majority would be of moderate strength.

**Research Question 4.** What are the relationships between academic achievement and neuropsychological abilities? How do these relationships look at different age years in school

age children? It was expected that the strongest relationships would be with the domains of working memory, executive function, motor, language and processing speed. It is expected there would be some variability between age groups in the relationship between academic achievement and neuropsychological abilities, as found in previous literature with executive functioning (Morales, 2015).

**Research Question 5.** What assessment measures do psychologists in New Zealand administer when assessing cognitive and neuropsychological functioning in children and why? Based on previous research it was hypothesised that the majority of New Zealand psychologists would be using the WISC-IV. It was hypothesised that test selection would be based on relevance, validity and credibility and on assessor factors such as training, experience and competence (Dunn & Dugdale, 2002).

**Research Question 6.** What are the opinions of psychologists on cultural impacts and influence of New Zealand on cognitive and neuropsychological assessments? It was hypothesised that opinions will reflect the perspective in the literature that NZ normative data is required (Dudley et al., 2016).

## **CHAPTER SIX: RESEARCH METHODOLOGIES**

The structure of this thesis by publication, means that some of the material in this chapter will be repeated in the subsequent three chapters. However, detail included here is not necessarily included in the manuscripts and is provided now to give thorough context. Firstly, the methodology of Study 1 and Study 2 will be presented together as they share the same research methodology, followed by methodology for Study 3.

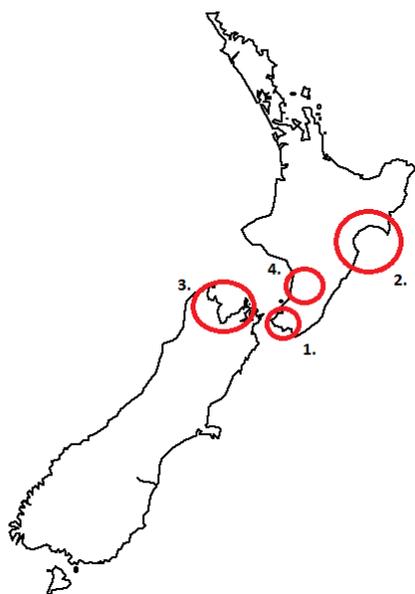
### **Methodology for Study 1 and 2**

#### **Ethics**

Ethical approval was obtained for the larger CPHR research project from the Human Disability Ethics Committee (reference no. NZ171E3013). Consent forms were obtained from all participants and participants had the right to withdraw from the study at any point. Assent was obtained from each child prior to the administration of the neuropsychological assessment. All research data was kept anonymous and in a secure location.

#### **Participants**

**Recruitment.** Schools in four regions around New Zealand (see *Figure 1* on the following page) were approached regarding the CPHR study. Schools were invited to participate based on their location to ensure a range of urban and rural schools required for the CPHR study. School decile was also a consideration in selection in order to have representation across school decile. Initial meetings with school principals were arranged where the research topic, aims and processes were discussed. Once a school confirmed their interest in the research, invitation letters were sent to the parents.

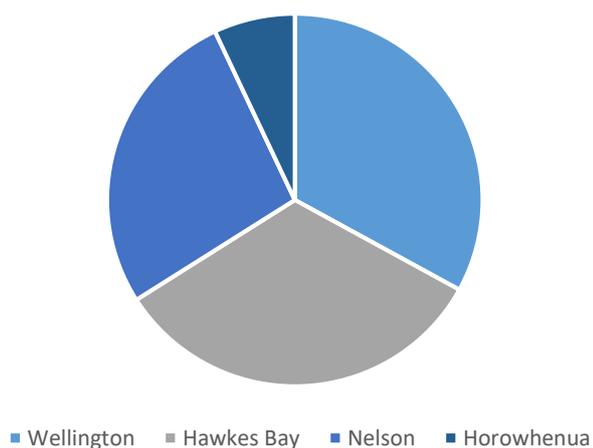


*Figure 1.* Study regions shown on map of New Zealand

*Note.* 1. Wellington, 2. Hawkes Bay, 3. Nelson Bays Region, 4. Horowhenua district

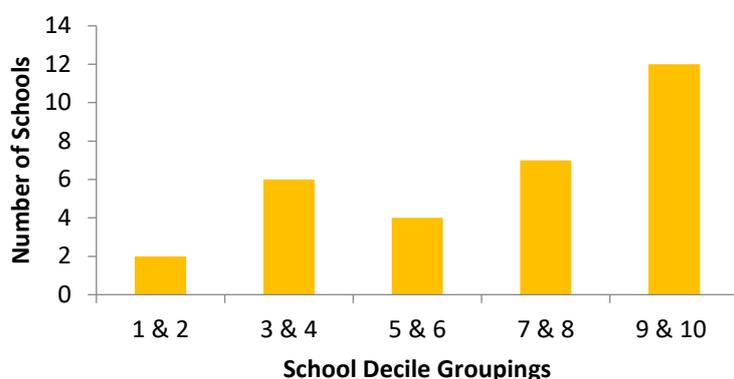
*Schools.* Ultimately a total of 30 schools were involved in the CPHR research project.

The proportion of schools involved from the four geographical locations is presented below in *Figure 2*.



*Figure 2.* Proportion of schools from geographical regions

The representation across school deciles<sup>3</sup> can be seen in *Figure 3* below.



*Figure 3.* Distribution of schools across decile value

*Response Rate.* The overall response rates were lower than anticipated. In February 2015 the response rate was 14% from the Wellington region. A trend was also observed with lower initial response rates from lower decile schools.

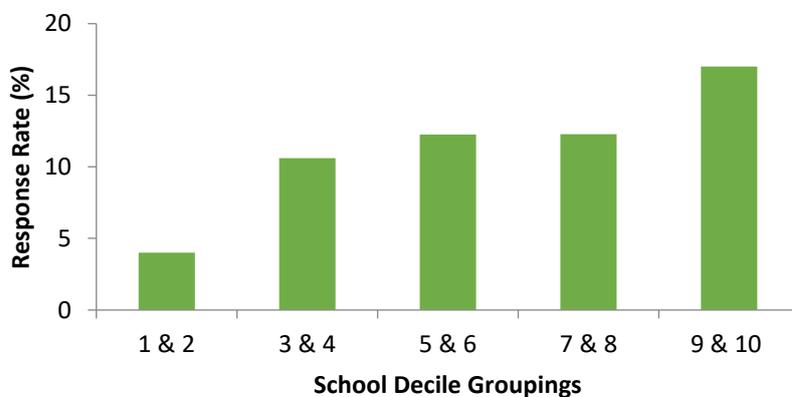
Discussion of ways to increase response rate from both a regional perspective and a school decile perspective was a focus in the researcher group discussions. A major consideration was that low response rate could be due to the length of the questionnaire in Phase I of the CPHR study. The length of this questionnaire was discussed on numerous occasions, in particular whether an on-line version might have suited some more than the 47-page hard-copy. However, it was decided the length was necessary for the amount of data the CPHR study required and an online option was not supported by CPHR researchers. Alternative ways were brainstormed frequently during the project to increase response rate. Methods that were implemented included; presentations at school assemblies, parent

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<sup>3</sup> Decile is the socio-economic position of a school's community. Rating is 1 to 10. Additionally, in summary a schools funding is determining by decile, the lower the decile the more funding is received.

information sessions, a research stall at school fairs, providing teaching of a science activity for participating schools and offering support to complete questionnaire over the phone.

Increased recruitment efforts in Wellington region did increase the response rate 2% from February 2015 to November 2016. The final response rates, for each region were; Wellington 16%, Hawke’s Bay 11%, Horowhenua District 16% and Nelson 11% with an average overall average response rate was 13.3%. The final response rates across school deciles are shown below on *Figure 4*.



*Figure 4.* Final response rates across School decile

*Children.* Of the 445 children involved, 221 (49.7%) were female and 224 (50.3%) were male. All children were between 6 and 11 years of age. Age during testing and ethnicity demographics are summarized in Table 1. As evident in Table 1, our sample of participants had over-representation of NZ European, MELAA and other codes of ethnicity and under-representation of Maori, Pacific and Asian children than representative of NZ population. The implications of this are discussed in Chapter 10.

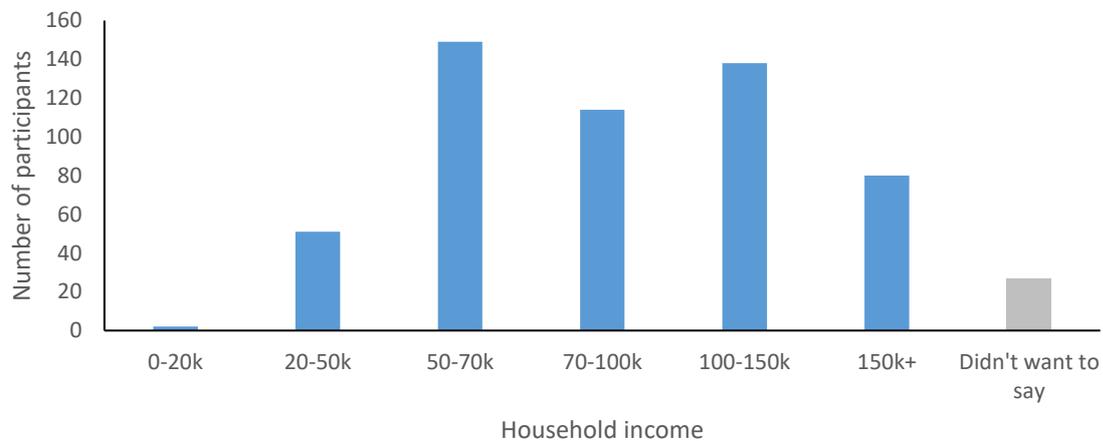
Table 1

*Age and Ethnicity of Participants*

Demographic Characteristic		
Age at testing	<i>n</i>	
6	91	
7	90	
8	79	
9	87	
10	64	
11	34	
Ethnicity <sup>1</sup>	%	2013 NZ Census (%)
NZ European	78.6	74
Māori	9.6	14.9
Pacific	1.3	7.4
Asian	4	11.8
MELAA	2	1.2
Other	4	1.7

*Note.* <sup>1</sup> Ethnicity was prioritised based on Ministry of Health codes (Ministry of Health, 2004). MELAA = Middle Eastern, Latin American or African.

The Socio-Economic Status (SES) estimated by school decile indicated a skew towards higher SES. This was congruent with the spread of household income of the children as shown in Figure 5.



*Figure 5.* Average household income of participants

**Exclusion Criteria.** Children were excluded if they were unable to complete the assessment. Two children were excluded, one was non-verbal and a second child was unable to sit in his chair, due to severe hyperactivity. 16 children with diagnoses reported by their parents<sup>4</sup> were included as they were able to complete the assessment.

### **Neuropsychological assessment**

The test selection process included long discussions due to the number of possible measures that could have been used. Questions arose as to, what measures are most commonly used to assess cognition and neuropsychological ability? Why? Are these measures going to be appropriate for New Zealand children, given so many are developed from overseas? The aim of the neuropsychological assessment was to assess across the cognitive domains, using age appropriate, recent and psychometrically reliable. Consideration into the total length of testing took into account the age of the child, the school day and it was eventually decided to aim for approximately one hour. Attempting to select measures that were also enjoyable for the children was another consideration. The requirements of the larger study for the neuropsychological assessments necessitated that the assessments cover the cognitive domains.

Based on the different number of cognitive assessment measures used for assessing children and consideration to the test selection process (as detailed in Chapter 4) a number of possible neuropsychological measures were discussed and reviewed during a panel test selection process. The test selection process involved a thorough discussion with the supervisor, the author and research colleagues and took place over two days. The selection panel included both males and females of various ages and a cultural advisor was consulted. The basis for the decision to select specific measures is summarised below in

Table 2.

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<sup>4</sup> Parental reported diagnoses of the 16 children: 5 dyslexia, 4 ADHD, 2 mild Autism, 2 Asperger's, 2 developmental delay, 1 mild concussion.

Table 2

*Measures reviewed for selection and reasons for test selection decisions*

Cognitive Domain	Test Name	Selected	Basis of Decision
Processing Speed	WISC-IV Coding	Yes	Evidence based & quick to administer
	WISC-IV Symbol Search	No	Time constraint
Memory	NEPSY-II Narrative Memory	Yes	Verbal memory & access to materials
	NEPSY-II Memory for Faces	Yes	Immediate & delayed component
Attention	TEA-Ch Sky Search	Yes	Motor function rule out & game-like
	NEPSY-II Auditory Attention & Response set	Yes	Assesses both attention & executive function
	N-back	No	Time constraint
Social Perception	NEPYS-II Theory of Mind	Yes	Only subtests to assess social perception in a neuropsychological measure for children
	NEPSY-II Affect Recognition	Yes	
Working Memory	AWMA Listening Recall	Yes*	Evidence based & computerised materials
	AWMA Spatial Recall	Yes*	Evidence based & computerised materials
	WISC-IV Digit Span	No*	No access to materials
	WISC-IV Letter Number Sequencing	No	Time constraints
Language	NEPSY-II Comprehension of Instructions	Yes	Had access to materials
	WISC-IV Comprehension	No	No access to materials
	WISC-IV Vocabulary	No	No access to materials
Executive Function	NEPSY-II Auditory Attention and Response set	Yes	Assesses both attention & executive function
	NEPSY-II Animal Sorting	Yes	Game-like for interest
	NEPSY-II Inhibition	Yes	Had access to materials
	DKEFS Colour-word Interference	No	Only appropriate for children age 8+
Motor Function	Coin Rotation	No	Specialized equipment required
	NEPSY-II Finger Tapping	Yes	Convenient & had access to material
	Computerised Finger Tapping	No	Less efficient, required specialised equipment

*Note:* \* = Initial decision to include these measures was changed during data collection.

*Changes made.* There were some decisions made during the test selection process in order to ensure the measures and subtests selected were appropriate for both the participants and in the context of this research.

In the Theory of Mind subtest in the NEPSY-II, changes were made to some in order to make the language more appropriate for New Zealand children. This process involved consultation with a cultural advisor and father of New Zealand children. This process followed similar procedure on language adaptation outlined in the WISC-IV Australian and New Zealand Standardisation Project (Wechsler, 2016). The changes made for the administration of Theory of Mind are summarised in Table 3 below.

Table 3

*Changes made in the Theory of Mind Subtest for the NEPSY-II*

Original Name or Word	Alternative Name or Word Used
Ming	Mandy
Sheryl	Sophie
Luz	Liz
Mama	Mum
Mom	Mum
Laurie	Laura
Eric	Aaron
Uncle Carlos	Uncle Charlie
Brandon	Mathew
Recess	Morning tea
Fun House	Haunted House
Denise	Daisy
Audrey	Ashleigh
Reggie	Regan

A second administration change was made regarding administration of the Sky Search subtest in the TEA-CH. The intended method for administering this subtest is for participants to use a non-permanent marker on a laminated sheet of A3 paper to circle pairs of identical spaceships however in the current research, the test material sheets were photocopied so a hard copy of the test result was kept for each participant. This was important to allow for re-

scoring to calculate inter-rater reliability and this would not have been possible with a reusable laminated sheet.

In the early stages of data collection two subtests were used from the Automated Working Memory Assessment (AWMA) to assess the cognitive domain of working memory (Listening Recall and Spatial Recall). However, early on it became apparent that the majority of the children struggled to understand the instructions, requiring multiple explanations. As these subtests were already considerably long (approximately 15 minutes), the decision was made to find an alternative test of working memory and these two subtests were removed. The Digit Span subtest in the Wechsler Intelligence Scale for Children (WISC-IV) was used instead as the measure of working memory. Children who had completed the AWMA were recorded as having missing data for the Digit Span subtest.

***Order of Test Administration.*** The order of test administration (see Table 4 on the following page) was determined to ensure that no single cognitive domain was consecutively assessed. One consideration to the testing order was with the Memory for faces subtest, which has a delayed component. The initial component of memory for faces was administered early to allow for sufficient time to pass before the delayed component was administered. In addition to memory for faces a second subtest (affect recognition) involves looking at pictures of children's faces. Therefore, the affect recognition subtest was specifically placed after the delayed components of Memory for faces to reduce confusion.

Table 4

*Neuropsychological Administration Order*

Subtest	Test	Order	Cognitive domain
Sky Search	TEA-CH	1	Attention
Memory for faces - Immediate	NEPSY-II	2	Memory (Visual) & Learning
Auditory Attention & Response Set	NEPSY-II	3	Attention & Executive Function
Digit Span	WISC-IV	4	Working Memory
Narrative Memory	NEPSY-II	5	Verbal Memory
Inhibition	NEPSY-II	6	Attention & Executive Function
Finger Tapping	NEPSY-II	7	Motor Skills
Coding	WISC-IV	8	Information Processing Speed
Memory for faces – Delayed	NEPSY-II	9	Memory (Visual) & Learning
Comprehension of Instructions	NEPSY-II	10	Language
Affect recognition	NEPSY-II	11	Social Perception
Theory of Mind	NEPSY-II	12	Social Perception
Animal Sorting	NEPSY-II	13	Executive Function

**Feedback.** No immediate feedback on performance was given to either the participants or their parents. However, some time later, a summary of their child's scores was sent via email to parents who requested feedback whilst making it clear that the assessment had been a short screen involving tests were selected for research purposes.

### **National Standards<sup>5</sup>**

National Standards were a Ministry of Education initiative to outline clear expectations for the knowledge and skills children in New Zealand need to achieve at each level, from year 1 to year 8. A child's achievement is categorised by their teacher as being; above, at or below the standard in three achievement areas; reading, writing and mathematics.

While a number of the achievement assessment measures (discussed in Chapter 4) could have been used to determine a child's achievement, due to the nature and scope of this project, using the child's national standards was the most appropriate method to obtain

<sup>5</sup> The elimination of National Standards due to a change in government during the writing of this thesis is discussed in Chapter 10

information regarding each participant's achievement. The national standard scores for the children in the study were obtained through the schools.

### **Procedure**

The procedure for this study followed the first two phases outlined in Chapter 1. Phase I began with initial recruitment meetings arranged with school principals. Once the principal and Board of Trustees of each school confirmed participation, research information and consent forms were sent to parents. On return of consent forms, parents were sent the questionnaire with a freepost return envelope.

Phase II began with a subset of parents who were sent a letter informing them that their child had been selected to participate in the neuropsychological assessment. Parents were invited to contact the researchers if they had any questions about the neuropsychological assessment, or if they or their child did not want to participate.

The invitation to participate in Phase II was initially based on the CPHR research aim of assessing 150 urban, 150 rural and 150 farmer's children. It was hypothesised that the Wellington region would include urban children and the rural and farm-living children would be in the other regions (Hawke's Bay, Nelson and Horowhenua regions). However, due to recruitment issues mentioned above and time constraints with the research project, all participants who completed Phase I were invited to participate in Phase II until sufficient neuropsychological assessments had been completed in a region. After this time, participants were selected for Phase II based on their geographical location to ensure representation for the larger study. However, the larger study had less representation in the farmer's children group than had originally been aimed for.

A few weeks after the invitation letter for phase II was sent out, school principals were contacted to arrange and organise the neuropsychological testing. The schools were

asked to provide a space that was ideally quiet, comfortable and with adequate lighting in order to ensure standardised testing environments. However, due to the reality of working alongside primary schools, the environment in which the neuropsychological assessments were administered varied between and within each school. Examples of where the assessments took place included; empty classrooms, resource rooms, staff rooms, libraries and principal's offices.

Children were excused from their classroom for approximately one hour during a typical school day to participate in the neuropsychological assessment. It was explained to the children that their parents had agreed for them to be part of a research study and they were asked if they had any questions. Assent was gained from each child before proceeding. On one occasion a child did not want to participate until he had spoken to his mother. The following day after the child had spoken to his mother about the research, he wanted to participate. The assessments were completed on a one-to-one basis with the researcher, in the order outlined in Table 4. At the end of the assessment the children were offered to a small item (pen, pencil and eraser) from a treasure box to thank them for their time. The children were asked if they had any other questions and the researcher walked with them back to their classroom. Due to the nature of working within the hours of school, four children could be assessed per researcher per day. Additionally, with the dynamics of working within primary schools and with young children, it was more often three children per researcher per day.

For eight children (1.8%) the neuropsychological assessments occurred at their home. This occurred either when the parents felt that the child would be more comfortable completing the assessments in their home than at their school or if the child had changed schools between recruitment and data collection. Home visits were arranged at a time that suited the family. A quiet, comfortable space with adequate lighting was also requested in these cases. For each house visit, the researcher made contact with research colleague before

the home visit stating the address and time of appointment and with the same colleague at the conclusion of the home visit. The assessment procedure at the home visits was the same at the school, i.e., on a one on one basis for approximately hour and the child could select a small item from a treasure box at the end of the assessment to thank them for their time and efforts. The child and family were again thanked for their time and participation in the study and the researcher left the home.

The neuropsychological assessments were completed during the school terms between May 2015 and December 2016. When the assessments were completed each school was given a \$200 voucher to be used in a way most beneficial for the school to thank them for their participation (e.g., book vouchers or sports equipment).

### **Preliminary Considerations**

*Inter-rater reliability.* Inter-rater reliability was calculated for the five researchers involved in the neuropsychological assessment administrations. This was calculated using 25 participant's data which was shadow-scored by a second administrator. The average agreement across the two administrators was computed and was found to be 89.5% for the NEPSY-II subtests and 100% for the TEA-Ch and WISC-IV subtests. This indicates adequate reliability and consistency across the five researchers. The percentage of inter-rater agreement with the NEPSY-II in the current study is consistent with the standard of inter-rater agreement between administrators who collected data for the development of the NEPSY-II (90%; Korkman et al., 2007).

*Effect of Administrator.* A multivariate analysis of variance was conducted in order to assess the impact of the administrator on the participants' test scores. The dependent variables were the 17 raw scores for each participant and the predictor variables were the test administrators (5 administrators). A main effect was found for test administrator ( $p = .000$ ),

which was further explored using post-hoc analysis. Post-hoc tukey test found a statistically significant difference on the NEPSY-II finger tapping task for researcher 2, which suggests that this researcher did not administer this task the same as the other researchers..

Specifically, researcher 2 recorded more children completing the task in 4 seconds (i.e., at a quicker rate) compared to the other researchers. The implications of this when converted to scale scores and on the research findings are discussed in Chapters 7 and 10.

***Effect of Region.*** Effect of region on performance is an important consideration as the larger project run by CPHR initially selected from different regions due to expected variations in level of pesticide exposure<sup>6</sup>. A multivariate analysis of variance was conducted in order to assess the impact of region on the participants' test scores. Dependent variables were the 17 scores for each participant and predictor variables were regions (Wellington, Hawkes's Bay, Nelson or Horowhenua). No main effect of region was found ( $p = .111$ ) indicating no significant difference on participants scores between the four regions.

***Scoring and data entry.*** The subtests from the WISC-IV and TEA-Ch were scored manually by the administrator and were double checked. Computer assistant software was used for the subtests from the NEPSY-II. The computerised data was entered by CPHR and all data entry was double entered to minimise error. When there was incongruency in data entry, the original data was checked for the correct response.

### **Methodology for Study 3**

#### **Ethics**

A low-risk ethics notification was obtained for the survey through Massey University (see Appendix D).

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<sup>6</sup> Please note: the analysis of pesticide exposure in the CPHR study uses a number of factors to consider level of pesticide exposure in addition to the initial selection by region. The results of the CPHR analyses are not completed at the time of the writing this thesis.

## Survey Design

The survey was designed in consultation with three psychologists who administer cognitive measures with children. It was developed to be an online survey that would take approximately 20 minutes to complete. The survey consisted of three sections a) clinical practice (country of training, scope of practice, current work sector; years and frequency of experience), b) test selection and c) cultural considerations, which will be described below. The online survey is presented in Appendix F.

The test selection section, b, focused on the frequency of use and reasons explaining use for measures. For clarity, measures were classified as either comprehensive measures or domain specific measures. Comprehensive measures included the WISC-IV<sup>7</sup>, NEPSY-II, Child Memory Scale (CMS), Wechsler Preschool and Primary Scale of Intelligence (WPPSI-IV), Delis Kaplan Executive Function System (DKEFS) and Stanford-Binet Intelligence Scale (SB5) and respondents were also asked about subtest use for these measures. Domain specific measures included for example the Stroop task and Conners Continuous Performance Test (CPT-3), as well as informant scales such as Adaptive Behavioural Assessment System (ABAS-II). Frequency of test use when completing a cognitive or neuropsychological assessment was determined on a 5-point Likert scale based on use when completing a cognitive or neuropsychological assessment (always use, almost always use, sometimes use, almost never use and never use). Respondents were able to endorse reasons *against* using a test from a given list as well as provide additional reasons explaining test use in an open comment box. The survey also asked about use of computerised administration and scoring and measures of effort. Suggested measures had been compiled from resources such as; professional practice of psychology in Aotearoa New Zealand (Eatwell & Wilson, 2016),

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<sup>7</sup> Due to the recent updated of the 5<sup>th</sup> WISC edition, if respondents had started using the WISC-V they were encouraged to respondent based on their use of WISC-IV.

ACC Neuropsychological Assessment Services (ACC, 2009) and recent literature on neuropsychological assessment (e.g., Lezak et al., 2012).

The third part of the survey, contained open-ended questions on cultural appropriateness and need for NZ normative data, as well asking what cultural adaptations respondents made to their administration.

### **Procedure**

Invitation to participate in the survey was distributed via a link in the June 2016 New Zealand Psychological Society (NZPsS) Connections magazine and through an email sent to the members of the New Zealand College of Clinical Psychologists (NZCCP), the New Zealand Special Interest Group in Neuropsychology (NZSIGN) and the Massey University Psychology Clinics (see Appendix E). Participants were also recruited through word of mouth within the psychological community. The survey was accessible online from June to August 2016. Due to this manner of recruitment there is no way to accurately determine the representation of the sample.

### **Data Analysis**

The survey was analysed using SPSS 24. Although 97 psychologists started the survey only 66 (68%) responses could be analysed due to varying degrees of missing data. Quantitative results were analysed using descriptive statistics while the brief open-ended qualitative comments were analysed in terms of frequencies of most common survey responses similar to previous literature (e.g., Barker-Collo & Fernando, 2015; Brooks, Ploetz, & Kirkwood, 2016).



The following page presents Study 1 as a research manuscript in format for journal submission. An earlier version of this study was presented at the *International Neuropsychological Society Annual Congress* in July 2017 (see Appendix I: Conference Presentation).

**CHAPTER SEVEN: AGE EFFECTS IN NEUROPSYCHOLOGICAL  
MEASURES FOR TYPICALLY DEVELOPING CHILDREN AGE 6 TO 11 YEARS**

Kate S. Ross-McAlpine<sup>1</sup>, Janet M. Leatham<sup>1</sup>, Ross A. Flett<sup>2</sup>, Jeroen Douwes<sup>3</sup>

1. School of Psychology, Massey University, Wellington, New Zealand.
2. School of Psychology, Massey University, Palmerston North, New Zealand.
3. Centre for Public Health Research, Massey University, Wellington, New Zealand.

## Abstract

**Aims:** The current study had two aims to address the lack of research into typical neuropsychological development in middle childhood: 1) To clarify the extent to which the results of New Zealand children correspond to standard overseas normative groups, 2) To explore the age effects of neuropsychological development of the cognitive domains in typical developing children through middle childhood.

**Method:** The neuropsychological development of typically developing children aged 6 to 11 years was investigated through analysis of 445 neuropsychological assessments conducted as part of a larger study. Sub-tests of the NEPSY-II, WISC-IV and TEA-Ch were used to assess attention, memory, motor function, language, information processing speed, executive function and social perception. The assessments were conducted individually in primary schools across four regions of New Zealand.

**Results:** 1) Scaled scores of the NZ sample were within  $\pm 4$  standard deviation scaled scores of the overseas normative groups for all tests except finger tapping and animal sorting (NEPSY-II). 2) Age effects were found for all measures of cognitive domains, with the most significant improvement between ages 6 and 9 years.

In summary, significant and large age effects were found across all measures of cognitive domains in 445 typically developing New Zealand children. The research implications for neuropsychological development and assessment are discussed.

## **Introduction**

In 2001 Korkman identified the neuropsychological development of children in the school years (5 to 12 years) as being an under-researched area (Korkman, 2001). As Bauer et al., (2011) pointed out, this may have been partly due to a suggestion made at the time that developmental changes during middle childhood (6 to 11 years) were less pronounced than in infancy or adolescence. Further, there was a research focus on neuro-atypical rather than neuro-typical children. Yet understanding the nature of typical neuropsychological development during this period would allow pathways of atypical cognitive development for children in various clinical groups to be established (Hughes & Leekam, 2004).

Since Korkman's 2001 statement, research has explored age effects often using the Developmental Neuropsychological Assessment, NEPSY (Korkman, Kemp, & Kirk, 2001) and its successor the NEPSY-II (Korkman et al., 2013; Rosenqvist et al., 2017). The NEPSY was developed to assess neuropsychological development across five cognitive domains (attention and executive functioning, language, memory and learning, sensorimotor and visuospatial processing) during the school years (5-12 years). Korkman, Kemp, & Kirk, (2001) reported development to be rapid between 5 to 8 years and more moderate between 9 to 12 years. Recently, Korkman et al., (2013) investigated neurocognitive development with the 2007 NEPSY-II normative data for children age 5 to 16 years, and included data for a new social perception domain. They found cognitive development during middle childhood fluctuated with more rapid development between 5 to 9 years. Nonlinear development in all subtests was also reported, with each subtest dependant on a combination of cognitive capacities.

More recent research has investigated neuropsychological development with the NEPSY-II in children from USA, Finland and Italy (Rosenqvist et al., 2017). This research

confirmed age effects from 5 to 15 years of age and investigated cross-cultural differences in neurocognitive performance from historic normative samples from 2007, 2008 and 2011 (Rosenqvist et al., 2017). These authors found US children performed lower than European children on visuospatial, constructional and fine-motor abilities. They also found that Italian children performed better than children from Finland and the USA on emotion recognition ability. Memory for faces did not differ significantly between countries (Rosenqvist et al., 2017).

Research has also been conducted using the NEPSY-II-NL, a validated Dutch adaptation of the NEPSY-II (Mous et al., 2017). Effects of age, gender and intelligence were investigated with performance on the NEPSY-II-NL and congruent with previous literature they found age effects for majority of tasks, with the exception of Statue. They attributed this exception to a small sample size. In their sample, girls outperformed boys, with the exception of visuospatial tasks. Their non-verbal measure of IQ was most strongly correlated with visuospatial tasks. These authors commented on the lack of research on neuropsychological development with typically developing school age children.

In summary, the research focusing on age effects of the development of multiple cognitive domains during middle childhood has mostly been conducted using the NEPSY and NEPSY-II. Furthermore, the literature utilized normative samples, often historic.

### **Age effects of cognitive abilities**

The understanding of age effects during neuropsychological development has been informed by the literature on the development of specific cognitive abilities. This research which is discussed below, often explores the differences between typically developing children and children with atypical development.

The development of *attention* varies during childhood, with most evidence suggesting rapid development until age 10 and gradual development thereafter (Egami et al., 2015; Vakil et al., 2009). A recent article using an attentional network task found large improvement between 6 and 7 years (Lewis et al., 2016). The pattern of development varies between different aspects of attention, with significant development of divided attention at 7 to 8 years and of selective attention at 8 to 9 years (Zebec et al., 2015). Sobeh and Spijkers (2013) found age-related improvements across all aspects of attention in Syrian and German children aged 5 to 12 years. Additional observations included Syrian children providing slower responses with greater variability and making more errors than German children.

Many different aspects of *memory* have been the focus of developmental research, including short term, working memory (Cowan, 2014), implicit and episodic memory, learning and long term memory (Lloyd & Miller, 2014; Schneider, 2010). In an early study of memory, specifically the developmental trajectory for the capacity to register new information, Anderson, Northam, Hendy, & Wrennall, (2001b) reported an improvement with age (from 7 to 13 years), with specific increases at age 8 and age 12. Working memory which is frequently measured using span tasks, such as the n-back, increases during development (Bock, Gallaway, & Hund, 2015; Pelegrina et al., 2015), with specific spurts identified at age 7 and another at 10-11 years (Demetriou et al., 2013). Recent research in Japan by Egami et al., (2015) associated the greater accuracy of 12 year old children on a working memory task (compared to the group of children 7-9 years) with maturation of the hippocampus. The need to further understand normal memory performance at different ages is recognised in the literature (Cowan, 2014).

*Processing speed* increases substantially in childhood, more rapidly than in adolescence, with the age-related change best explained by a quadratic rather than linear

model (Kail & Ferrer, 2007). More recent research by Demetriou et al., (2013) found unstable change between 4 to 6 years, with change becoming systematic from ages 6 to 7 until early adulthood but with two spurts noted at 7-8 and 11-12 years of age.

Both fine and gross *motor abilities* develop in childhood, with tasks of fine motor dexterity being of interest in a neuropsychological assessment (Scott, 2011) due to the relationships between motor skills and cognitive ability (Davis, Pitchford, & Limback, 2011; Jenni, Caflisch, & Rousson, 2013; van der Fels et al., 2015). Gasser, Rousson, Caflisch, & Jenni, (2010) used 10 motor speed and movement tasks from the Zurich Neuromotor Assessment, and found that the most significant improvements in *motor speed* tasks occur between 5 and 10 years, with the dominant side developing faster than the non-dominant side.

The interest in *social perception* as a cognitive ability in neuropsychological research has been recent. However, theory of mind has been studied extensively outside of neuropsychological research (Wellman, 2010). Research by Korkman, et al., (2013) within a neuropsychological framework found that social perception (as measured by theory of mind and affect recognition on the NEPSY-II) was one of the earliest cognitive abilities to reach maturation at 11-12 years of age, with rapid development more apparent during 5 to 9 years.

Early developmental research argues for three stages in the development of *executive function*, the first at age 6 with ability to resist distraction, the second at age 10 with impulse control and hypothesis testing, and a final stage in early adolescence involving motor sequencing and planning skills (Welsh & Pennington, 1991). Subsequent research suggested that these developmental ‘spurts’ might not be quite as rigid or categorical with Anderson (2002) identifying critical developmental periods for executive functioning between 7 and 9 years and maturing by 12 years of age. More recent research by Qian, Shuai, Chan, Qian, & Wang, (2013) found children exhibited stability for inhibition, working memory and planning

at ages 11-12, while the ability of shifting kept developing until age 13-15. Longitudinal research by Brydges, Fox, Reid, & Anderson, (2014) indicated that specific executive functions (inhibition, shift, working memory) are indistinguishable until around 9 years of age, but from 10-11 years develop at separate rates.

### **Cultural considerations of neuropsychological development with children**

There has been an increase in concern over time in the literature for consideration of cultural differences in neuropsychological performance of children (Byrd, Arentoft, Scheiner, Westerveld, & Baron, 2008; Olson & Jacobson, 2015). Understanding the impact of culture is critical in determining if measures can be administered outside the normative sample. It is well documented in the literature that culture impacts on neuropsychological assessment (Dudley et al., 2016; Olson & Jacobson, 2015) and as such assessors need to be aware of this during administration (Horton, 2008; Wong, 2006). Normative data for different cultural groups is recommended in the literature (Feigin & Barker-Collo, 2007; Rosenqvist et al., 2017), however this doesn't often exist. Therefore, the consideration of culture impacting on neuropsychological performance is of particular importance in environments where normative samples for commonly used measures do not exist. Research has called for the establishment of measures across different cultures (Byrd et al., 2008).

Recent research investigating the age effects discussed above has considered cultural differences and explored age effects in different countries (Rosenqvist et al., 2017; Rosselli, Ardila, Navarrete, & Matute, 2010; Sobeh & Spijkers, 2013). For example, a recent study explored the historical context for cultural and ethnic differences of neuropsychological test performance between Spanish and English adults (Ojeda, Aretouli, Pena, & Schretlen, 2016). In the literature on neuropsychological assessment with children, there has been a call for further cross-cultural research in neuropsychology (Rosenqvist et al., 2017).

The literature on cross-cultural neuropsychology in New Zealand is consistent with international literature (Dudley et al., 2016). Cultural bias in neuropsychological assessments with children in the New Zealand has been investigated (e.g., Fernando et al., 2003; Haitana et al., 2010). Most recently, Haitana, Pitama, & Rucklidge (2010) found that the Peabody Picture Vocabulary Test-III (PRVT-111) was largely appropriate with Māori children in mainstream schools but not for children attending Māori-medium schools, where results were more indicative of English language development than their overall language ability. These authors suggested adaptations such as more culturally appropriate target words (e.g., changing Porcupine to Hedgehog), and recommended inclusion of te reo Māori.

In summary, there has been limited research investigating the age effects of neuropsychological abilities in middle childhood. Research in this area would provide further clarification of age effects and the typical patterns of performance along developmental trajectories. There has been no research conducted in this area for New Zealand children.

The current research aimed to firstly compare a sample of New Zealand children with overseas norms for cultural difference assessment to determine with what confidence measures of neuropsychological ability in New Zealand can be used. Based on cross-cultural research in neuropsychology (e.g., Dudley et al., 2016) it was hypothesised that there would be differences between New Zealand children and overseas norms. Based on the recent research by Rosenqvist et al., (2017) it was hypothesised that our sample of NZ children would perform better on NEPSY-II subtests than USA norms. Secondly, the research aimed to investigate age effects and developmental trends on neuropsychological assessment measures. Based on previous research (Korkman, Kemp, & Kirk, 2001; Korkman et al., 2013; Rosenqvist et al., 2017; Rosselli et al., 2010), age effects for all measures of neuropsychological ability were expected.

## Method

### Participants

Participants were 445 children aged between 6 and 11 years who underwent a neuropsychological assessment as part of a larger epidemiology study. Demographic characteristics of the sample are outlined in Table 1. Features of our sample include a skewed age range in favour of younger age groups; with only 31 children in the 11-year-old age group and an over-representation of New Zealand European children.

Table 1

#### *Summary of Demographic Characteristics*

Variables	Age Group (years)						<i>Total n</i>
	6	7	8	9	10	11	
Gender							
Female	45	43	41	42	32	18	221
Male	46	47	38	45	32	16	224
Ethnicity <sup>1</sup>							
New Zealand European	68	71	66	68	52	25	350
Maori	11	9	6	8	6	3	43
Pacific	3	0	2	0	0	1	6
Asian	3	4	2	5	3	1	18
MELAA	1	3	0	1	2	2	9
Other	5	3	3	5	1	2	19
<i>Total n</i>	<i>91</i>	<i>90</i>	<i>79</i>	<i>87</i>	<i>64</i>	<i>34</i>	<i>445</i>

*Note.* <sup>1</sup> Ethnicity was prioritised based on Ministry of Health codes (Ministry of Health, 2004). MELAA = Middle Eastern, Latin American or African.

Children were excluded if they were unable to complete the assessment. Two children were excluded, one was non-verbal and a second child was unable to sit in his chair, due to severe hyperactivity.

### Neuropsychological assessment

The aim of the neuropsychological assessment was to assess across the cognitive domains using age appropriate, recent and psychometrically reliable measures. The measures included selected sub-tests of the NEPSY-II, WISC-IV and TEA-Ch. Order of test

administration, as shown in Table 4, was determined to ensure that no single cognitive domain was consecutively assessed, and that there was sufficient time delay for delayed memory.

Table 2

*Neuropsychological Assessment Administration Order*

Order	Subtest	Test name	Cognitive domain
1	Sky Search	TEA-CH	Attention
2	Memory for faces	NEPSY-II	Memory & Learning
3	Auditory attention & response set	NEPSY-II	Attention & Executive Function
4	Digit Span	WISC-IV	Working Memory
5	Narrative Memory	NEPSY-II	Verbal Memory
6	Inhibition	NEPSY-II	Attention & Executive Function
7	Finger Tapping	NEPSY-II	Motor Skills
8	Coding	WISC-IV	Information Processing Speed
9	Memory for faces - Delayed	NEPSY-II	Memory & Learning
10	Comprehension of Instructions	NEPSY-II	Language
11	Affect recognition	NEPSY-II	Social Perception
12	Theory of Mind	NEPSY-II	Social Perception
13	Animal Sorting	NEPSY-II	Executive Function

**Procedure**

Children were recruited as part of a larger study. Their parents provided consent and completed demographic questionnaires. The neuropsychological assessments occurred in 30 schools. Each school was asked to provide a quiet, comfortable space with adequate lighting in order to ensure a standardised testing environment. Children were excused from their classroom for approximately one hour during a school day to participate in the assessment. Assent was obtained from the children prior to completing the assessment and at the end of each child was offered an item (e.g., pencil or stickers) to thank them for their time.

**Results**

**Preliminary Analyses**

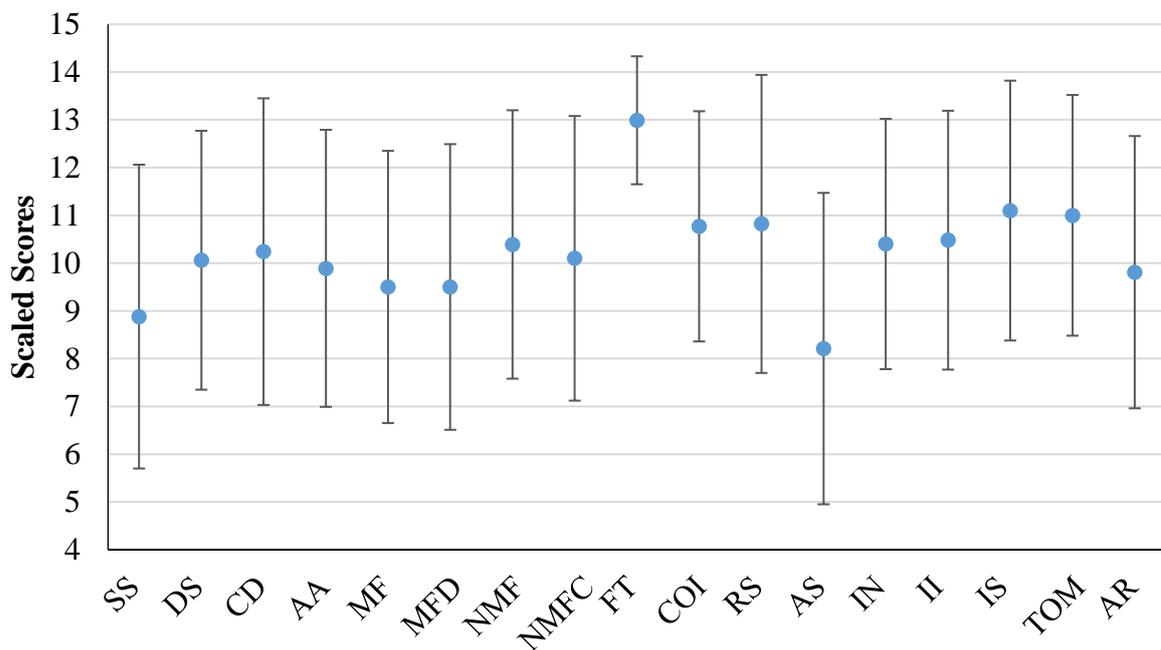
Multivariate analyses of variance were conducted in order to assess the impact of demographic factors on the participants' test scores. Dependent variables were the 17 scores for each participant and predictor variables were ethnicity and gender. No main effect of

gender ( $p = .334$ ) or ethnicity ( $p = .092$ ) was found which indicates no significant difference on scores between male and female children or children from different ethnic groups.

### Comparison with overseas normative groups

Scaled scores were used to compare the current New Zealand sample with norms obtained in the USA (NEPSY-II) and Australia (TEA-CH & WISC-IV) see *Figure 1*.

Normative groups have a scaled score mean of 10 and standard deviation of 3.



*Figure 1.* Means and standard deviations of subtests for New Zealand children aged 6-11 years.

*Note.* SS = Sky Search, DS = digit span, CD = Coding, MF = memory for faces, MFD = memory for faces delayed, NMF = narrative memory free recall, FT = Finger Tapping, COI = comprehension of instructions, RS = response set, AS = animal sorting, IN = inhibition naming, II = inhibition inhibition, IS = inhibition switching, TOM = theory of mind, AR = affect recognition.

Means for all subtests for the current New Zealand sample, fell within  $\pm 4$  standard deviation of the overseas mean normative scaled score of 10 with the exception of Finger Tapping (repetitions combined scaled scales;  $M = 12.99$ ,  $SD = 0.9992$ ) and Animal Sorting (animal sorting total scaled score;  $M = 8.21$ ,  $SD = 0.63$ ).

## Age Effects

One-way between subject ANOVA's revealed a significant effect of age on raw scores on all subtests at the  $p < .001$  level (see Table 3).

Table 3

*Mean, standard deviations of raw scores and ANOVA for effects of age*

Subtest	Total mean (SD)	<i>F</i>	$\eta^2$
Sky Search	5.41 (3.11)	18.51*	0.174
Auditory Attention	27.23 (3.17)	27.40*	0.239
Digit Span	13.459 (2.86)	17.03*	0.168
Coding	41.66 (10.80)	29.37*	0.331
Memory for faces	10.25 (2.23)	6.29*	0.066
Memory for faces - Delayed	9.89 (2.58)	4.53*	0.013
Narrative memory – Free recall	10.85(3.90)	25.14*	0.223
Narrative memory – Free & cued	25.01 (7.06)	28.44*	0.223
Finger Tapping	5.61 (1.31)	43.78*	0.335
Comprehension of Instructions	24.27 (3.90)	28.44*	0.244
Response set	31.57 (4.12)	6.61*	0.084
Animal Sorting	3.87 (2.32)	13.75*	0.171
Inhibition - Naming	58.16 (13.13)	65.86*	0.385
Inhibition - Inhibition	86.68 (24.52)	54.90*	0.428
Inhibition - Switching	116.69 (24.43)	20.79*	0.237
Theory of Mind	21.46 (3.60)	41.44*	0.321
Affect recognition	22.94 (5.12)	43.85*	0.500

*Note:* \* =  $p < 0.001$ , Degrees of freedom (df) = 5

The majority of the effect sizes (as measured by eta squared;  $\eta^2$ ) were large ( $>0.138$ ), two subtests were medium (memory for faces and response set) and one was small (memory for faces delayed).

The means scores for each age group on each subtest are depicted below in Figure 1. The age groups are depicted on the x axis and the y axis is specific for each subtest.

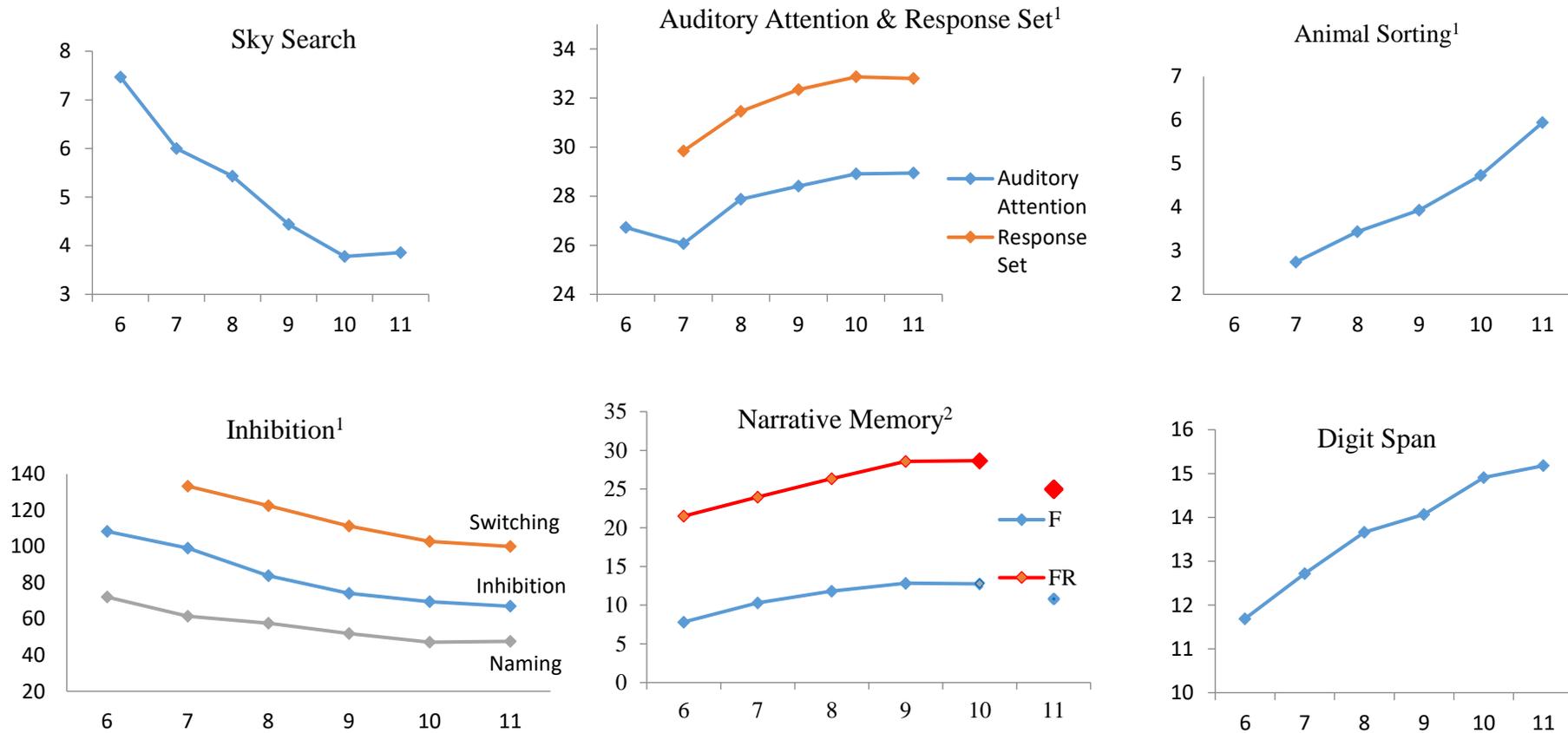


Figure 2.

Mean subtest scores for measures of neuropsychological ability.

Note. Horizontal axis shows age of children and vertical axis show subtest means. Sky search is overall score of attention; auditory attention and response set shows is overall accuracy, i.e., errors decrease with age; animal sorting is number of correct sorts; inhibition time taken in seconds; narrative memory-amount recalled; digit span total score.

<sup>1</sup>Response set, animal sorting and inhibition switching is only administered for children aged 7+.

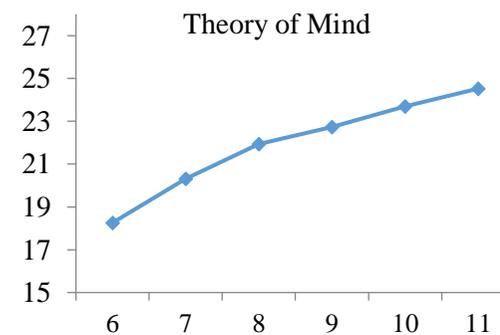
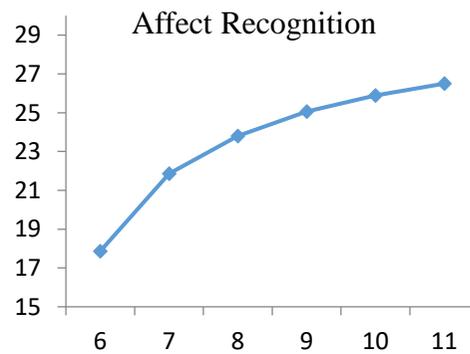
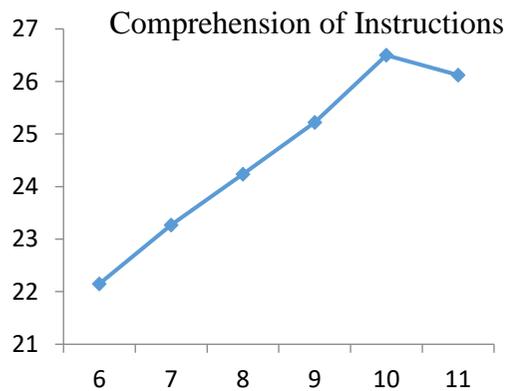
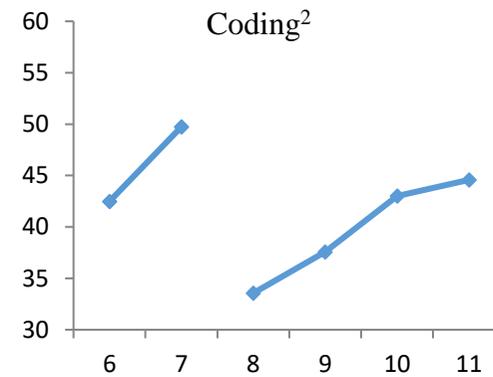
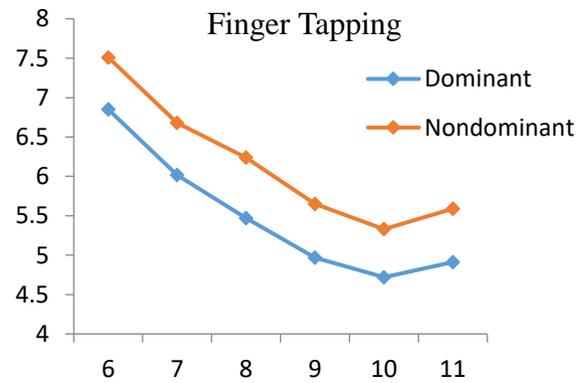
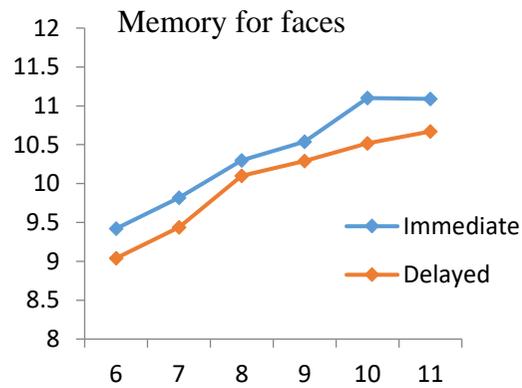


Figure 2. (Continued)

Note. Memory for faces shows correct recall for both immediate and delay; Finger tapping time taken in seconds; coding an increase in accurate processing over the two age dependent tasks; comprehension of instructions correct responses; affect recognition correct responses and theory of mind is correct response. <sup>2</sup>Two conditions for different ages indicated by break in line

Age effects were investigated further with a post hoc analysis using a bonferroni adjustment for each subtest. The mean differences between adjacent age groups were calculated and are shown in Table 4. The largest and most significant mean differences were evident between ages 6 and 9, with few significant differences evident after age 9.

Table 4

*Mean group differences for pair-wise comparisons of adjacent age groups*

Subtest	6 < 7	7 < 8	8 < 9	9 < 10	10 < 11
<b>Attention</b>					
Sky Search	1.44*	0.60	0.98	0.66	-0.75
Auditory Attention	-1.16	-1.85***	-0.54	-0.49	-0.35
<b>Processing speed</b>					
Coding	-7.14***	16.07*** <sup>1</sup>	-4.29*	-5.15*	-1.58
<b>Working Memory</b>					
Digit Span	-0.97	-1.00	-0.37	-0.87	-0.28
<b>Memory</b>					
Narrative – Free	-1.78**	-1.50	-1.11	0.15	4.85*** <sup>1</sup>
Narrative – Free & Cued	-2.68	-2.23	-2.42	0.86	10.17*** <sup>1</sup>
Memory for Faces	-0.46	-0.43	-0.24	-0.52	0.00
Memory for Faces Delayed	-0.39	-0.67	-0.17	-0.24	-0.15
<b>Motor Function</b>					
Finger Tapping - Dominant	0.84***	0.54*	0.51*	0.25	-0.25
<b>Language</b>					
Comprehension of Instructions	-1.17*	-0.92	-0.97	-1.28	0.37
<b>Executive Function</b>					
Response Set	na	-1.65	-0.85	-0.54	0.065
Animal Sorting	na	-0.77	-0.49	-0.75	-1.21
Inhibition - Naming	10.27***	3.83	6.01**	4.06	0.38
Inhibition - Inhibition	9.12*	15.43***	9.48*	4.76	2.54
Inhibition - Switching	na	11.023*	11.23*	7.55	3.76
<b>Social perception</b>					
Theory of Mind – Verbal	-2.05***	-1.62*	-0.80	-0.97	-0.83
Affect Recognition	-3.94***	-1.99*	-1.24	-0.85	-0.61

*Note:* \*\*\*p < 0.001, \*\* p < 0.01, \* p < 0.05. <sup>1</sup>Significant difference is likely accounted for by different test version between the age group

## Discussion

The present study investigated patterns of neuropsychological development and cross-cultural neuropsychology in a typically developing sample of New Zealand children aged 6 to 11 years.

### Comparison with overseas normative groups

The findings identified that the current sample of New Zealand children were within .4 SD of overseas norms for all subtests, with the exception of Finger Tapping and Animal Sorting. The hypothesis that some differences would exist between the current sample and overseas normative groups was supported.

In regards to finger tapping, previous research has found European children performed better than children from the USA on fine motor tasks (Rosenqvist et al., 2017), which is consistent with our finding of NZ children performing better than children from the USA on the NEPSY-II finger tapping task. An administrator effect on finger tapping found in preliminary analyses<sup>8</sup> was also considered to explain this finding. To examine the possible effect of the administrator effect, the weighted mean scaled scores for finger tapping were calculated without the researcher who was found to differ from other researchers. The mean scaled score was  $M = 12.96$ , compared to  $M = 12.99$  including the researcher. This difference of 0.03 scaled score without the researcher, indicates that administrator effect did not account for the research finding that New Zealand children performed better than US children on finger tapping.

Another possible explanation for the finding, was the time between the collection of the USA normative group in 2007, compared with the current studies data collection during 2015-2016. During this period children may have been slowly

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<sup>8</sup> A preliminary analysis found researcher 2 to be significantly different to other administrations on finger tapping (as discussed in Chapter 6).

exposed to more and more technologies /devices requiring fine motor dexterity (e.g., hand held devices, computers, smart phones and tablets) which may explain this finding. The Flynn effect was also considered as a possible explanation of however, is unlikely as the Flynn Effect has not been found to apply to motor skills tasks (Dickinson & Hiscock, 2011).

The finding that New Zealand children performed lower on animal sorting ( $M = 8.21$ ) could possibly be explained by the test order of administration, i.e., fatigue, as animal sorting was the final test to be administered to each child. However, the subtest administered prior to animal sorting did not have a low overall performance (Theory of Mind,  $M = 11$ ). Therefore, it seems unlikely that the overall lower performance on animal sorting by New Zealand children can be explained by order effects.

These findings have clinical implications for neuropsychological practice in New Zealand. There is the potential for results on the NEPSY-II to be incorrectly interpreted, for example a child scoring low on animal sorting could be incorrectly interpreted as an individual weakness. It is suggested that the use of finger tapping and animal sorting subtests should be used with caution. The existence of differences between samples, such as those found for animal sorting and finger tapping, indicates that New Zealand normative data would be beneficial (especially for these subtests) in ensuring accurate assessments.

### **Age Effects**

Statistically significant age effects were found for all measures of cognitive abilities which is consistent with previous research (Korkman et al., 2001, 2013;

Rosenqvist et al., 2017; Rosselli et al., 2010). The majority of measures had large effect sizes, however memory for faces had a medium and small effect size (immediate task and delayed task respectively) which may suggest that the ability to remember faces in our sample is only partially explained by age.

Post-hoc analysis identified that mean differences between adjacent age groups were larger and more significant for 6 to 9 years. This indicates that the development of the cognitive domains is more rapid during this age range. These findings are consistent with previous literature (Korkman et al., 2001, 2013; Rosenqvist et al., 2017).

There were no statistically significant differences between the adjacent age groups on four subtests (memory for faces, memory for faces delayed, response set, animal sorting or digit span). This indicates that these abilities develop more steadily as opposed to developing at rapid periods between specific age groups. Of these four subtests, two are discussed in previous literature with similar findings between adjacent age groups, minimal significant differences for memory for faces (Rosenqvist et al., 2017) and animal sorting (Korkman et al., 2013).

Between ages 10 and 11 an inverse effect of age was evident for finger tapping, comprehension of instructions and sky search. This has not been found in previous literature in this area. It is hypothesised that the 11-year old group performed at lower levels than the 10-year-old group due to the smaller sample size, (31 11-year-olds versus 67 10-year olds). It is also necessary to note some children turned 12 years old between recruitment and neuropsychological assessment, which likely effected the representativeness of the 11-year-old group. However, for the Narrative Memory subtest, the story read to the 11-year-old children is different to the other age

groups (story A is for 3-4, story B for 5-10 years and story C is for 11-16 years). This may suggest that it is too difficult for 11-year-old children, which was congruent with researcher observations.<sup>9</sup>

### **General Discussion**

The current research sought to explore patterns of neuropsychological development in a typically developing sample of New Zealand children by investigating effects of age and cultural comparisons. Firstly, scores of New Zealand children were compared to the neuropsychological measures normed in USA and Australia. New Zealand children were faster on a finger tapping task and provided fewer correct sorts on a card sorting task, than children from USA. Consistent with discussions in the literature (Feigin & Barker-Collo, 2007) it is recommended that New Zealand norms are used for more accurate assessments of New Zealand children. Secondly, consistent with findings across cultures age effects of neuropsychological ability in typically developing school age children was found, particularly the pattern of rapid development for ages 6 to 9.

The under-representation of the 11-year-olds as a group and over-representation of New Zealand European children were limitations of the current study. As mentioned, the representativeness of the 11-year-old group was likely affected by some children turning 12 years old between recruitment and neuropsychological assessment and therefore being excluded from the study. The under-representation of New Zealand Maori children in the study is also a limitation, as it constrains the ability of this research to meaningfully explore performance with

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<sup>9</sup> This is discussed further in Chapter 10

this minority group. Furthermore, it is possible additional differences between the New Zealand sample and the US sample would have been identified if the sample had been more representative of minority groups within New Zealand. The differences between the study sample and overseas normative samples (e.g. sample size; NEPSY-II  $n = 1,200$ , WISC-IV  $n = 851$  and current study  $n = 450$ ; and age range; NEPSY-II 3-16 years and WISC-IV 6-16 years and current study 6-11 years) are recognized as a research limitation. The results must be considered in light of these differences. Finally, it would also have been beneficial to have had a measure of visual-constructional ability as well as more subdomains of multifaceted cognitive domains.

Future directions for neurodevelopmental research in middle childhood should explore the underlying factors influencing the rapid development in children age 6 to 9 years. Additionally, different cultural influences that impact on neuropsychological performance and development should be explored. This may include the socio and historical cultural considerations as previously literature has explored (Ojeda et al., 2016). Understanding cultural influences on neuropsychological performance is critical to accurate assessment.

The following page presents Study 2 which is presented as a manuscript in format for journal submission.

**CHAPTER EIGHT: RELATIONSHIPS BETWEEN  
NEUROPSYCHOLOGICAL ABILITIES AND SCHOOL ACHIEVEMENT IN NEW  
ZEALAND AGE 6 TO 11 YEARS**

Kate S. Ross-McAlpine<sup>1</sup>, Janet M. Leathem<sup>1</sup>, Ross A. Flett<sup>2</sup>, Jeroen Douwes<sup>3</sup>

1. School of Psychology, Massey University, Wellington, New Zealand.
2. School of Psychology, Massey University, Palmerston North, New Zealand.
3. Centre for Public Health Research, Massey University, Wellington, New Zealand.

## Abstract

Previous research investigating relationships between neuropsychological abilities and academic achievement has been limited by investigating a few domains of functioning or small sample sizes. Furthermore, there has been no research conducted comparing neuropsychological ability with the National Standards of achievement which were used to assess achievement in New Zealand Primary schools from 2008-2017. The current research aimed to explore these relationships in a group of typically developing children age 6 to 11 years. Correlation analyses found expected moderate relationships between measures of neuropsychological ability. Intra-domain variability was evident most notably between executive functioning and social perception. The measures of ability with the most significant relationships with national standard achievement across the age groups were working memory, social perception, processing speed, executive functioning and language. Comparatively, non-significant relationships were found with measures of ability assessing memory and motor skills. Patterns in the relationships with neuropsychological ability and national standards across the age groups found the relationships to be strongest at age 6, 10 and 11 years and weakest at 7, 8 and 9 years. Research limitations and directions for future research are provided.

**Key words:** *neuropsychology; national standards; school achievement; middle childhood;*

## **Introduction**

The relationships between different neuropsychological abilities are important to consider during child neuropsychological development. There has been a number of research articles exploring the relationships between cognitive abilities during development in middle childhood (e.g., Bock et al., 2015; Davis et al., 2011; Diamond, 2000; Grazzani & Ornaghi, 2012; Luz et al., 2014; Wolfgang Schneider, 2014; van der Fels et al., 2015). However, this research is limited by the number of cognitive domains studied, often only one or two, as well as small sample sizes.

The relationships between neuropsychological abilities and academic achievement are also important to consider during this developmental period. The relationship between intelligence and school achievement has been studied extensively in the literature but remains somewhat divided, with some research finding certain cognitive abilities predict school achievement better than intelligence (e.g. attention as identified by Alloway & Alloway, 2009). Part of this argument is the idea that measures of intelligence often assess many cognitive domains and therefore an intelligence quotient derived from combining all scores is seen as conceptually meaningless (Ardila, 1999; Lezak et al., 2012; Morales, 2015).

Consideration of the relationships between specific neuropsychological abilities and school achievement in school age children is a growing research area (e.g., Demetriou et al., 2013; Mayes, Calhoun, Bixler, & Zimmerman, 2009; Rindermann & Neubauer, 2004; Zebec, Demetriou, & Kotrla-Topi, 2015). Strong correlations for example have been found with executive function in childhood (Best et al., 2011; St Clair-Thompson & Gathercole, 2006; Willoughby et al., 2012; Yeniad, Malda, Mesman, Ijzendoorn, & Pieper, 2013) and working memory (Lechuga et al., 2016).

Other research has considered the relationships between specific cognitive domains and specific achievement areas, such as mathematics, reading and writing. For example, mathematics has been found to be strongly related to working memory (Alloway & Passolunghi, 2011; Bull, 2009; Holmes & Adams, 2006; Passolunghi & Lanfranchi, 2012; Raghubar et al., 2010), motor skills (Cameron et al., 2016; Dinehart & Manfra, 2013; Pitchford et al., 2016; Son & Meisels, 2006) and processing speed (Passolunghi & Lanfranchi, 2012).

Recent research between different neuropsychological abilities and school achievements include associations found between reading achievement and language skills (Susana et al., 2015), working memory (Pham & Hasson, 2014; Susana et al., 2015) and motor skills (Dinehart & Manfra, 2013; Son & Meisels, 2006). Motor skills in preadolescent children have been found to strongly relate to both mathematics and reading comprehension (Geertsens et al., 2016). Writing achievement has been associated with working memory (Christopher et al., 2016; Kim & Schatschneider, 2017) and processing speed (Christopher et al., 2016; Cormier & Bulut, 2016; Rindermann et al., 2011). Both reading and writing achievement has been associated with executive functioning (Cantin, Gnaedinger, Gallaway, Hesson-McInnis, & Hund, 2016).

The relationship between ability and achievement is also informed by correlations between standardised psychometric measures. The Wechsler Intelligence Scale for Children (WISC-IV) manual reports correlations with the Wechsler Individual Achievement Test (WIAT-II) where FSIQ is noted to be the greatest predictor of total achievement, followed by the verbal comprehension index (Wechsler, 2003). The Developmental Neuropsychological Assessment (NEPSY-II) manual also reported correlations with the WIAT-II and found language (Comprehension of Instructions, Phonological Processing) and

memory (Narrative Memory, Sentence Repetition) and attention/executive function<sup>10</sup> (Clocks) the strongest correlates with academic achievement (Korkman et al., 2007). The relationship between neuropsychological abilities and achievement is obviously complex and recent literature on neuropsychological development suggests it is bidirectional (Rosenqvist et al., 2017).

The strength and nature of the relationship between abilities and achievement has been found to differ at different ages during childhood (Alloway & Passolunghi, 2011; Best et al., 2011; Floyd et al., 2008). For example, Alloway and Passolunghi (2011) found the relationship between working memory and mathematics differs between 6 and 8-year-old children, while Best et al., (2011) found the relationship between executive function and academic achievement to spike at age 6 and again age 8-9 and remained moderate across their age range 5 to 17. This indicates the need for careful consideration of age when exploring achievement and neuropsychological ability in childhood. There does not appear to be any research investigating the relationships between ability and achievement in different age groups or on the relationship between multiple cognitive domains and school achievement across age groups in typically developing school age children.

Between 2008 and 2017 achievement in reading, writing and mathematics in primary school aged children in New Zealand was assessed through National Standards with children rated as either above, at, below or well below the standard. At the time the National Standards were introduced concerns were raised about the haste at which they had been developed and implemented, i.e., that they had not been well tested (Bonne, 2016). Since their implementation, principals, teachers and parents have remained divided in their opinions on the role of the National Standards in student learning and how well they assess

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<sup>10</sup> NEPSY-II clusters attention and executive functioning in same domain

achievement (Bonne, 2016). Specific concerns have been discussed regarding culturally appropriate National Standards for Maori (Özerk & Whitehead, 2012), concerns for children with English as a second language (Smith, Anderson, & Blanch, 2016) and the impact on children who remain ‘below standard’ despite personal progress (Bonne, 2016).

To date, no research has explored the relationship between New Zealand National Standards of achievement with neuropsychological abilities. It is therefore unclear whether the National Standards are congruent with the established relationships between standardised measures of achievement and neuropsychological abilities. The research that has investigated relationships between neuropsychological abilities has focused on a few domains with small sample sizes (Davis et al., 2011; Luz et al., 2014). Further clarification of these relationships in typically developing children will provide a thorough understanding of neuropsychological development.

The current research had two main aims, firstly to explore relationships between *multiple* cognitive domains. Based on research in this area, moderate correlations are hypothesized. The second aimed to explore the relationships between national standards of achievement and neuropsychological ability at different ages. Based on previous literature on achievement and neuropsychological abilities (Alloway & Alloway, 2009; Christopher et al., 2016; Passolunghi & Lanfranchi, 2012; Son & Meisels, 2006; St Clair-Thompson & Gathercole, 2006; Susana et al., 2015; Willoughby et al., 2012) it was hypothesised that National Standards will be most strongly correlated with the domains of working memory, executive function, motor, language and processing speed. Based on literature on the relationship between executive functioning and academic achievement (Best et al., 2011) it was also hypothesised that at different ages variation in the strength of these relationships would be present.

## Method

### Participants

Participants were 445 children aged between 6 and 11 years who underwent a neuropsychological assessment as part of a larger epidemiology study. Demographic characteristics of the sample are outlined in Table 1. Features of our sample include a skewed age range in favour of younger age groups; with only 31 children in the 11-year-old age group and an over-representation of New Zealand European children.

Children were excluded if they were unable to complete the assessment. Two children were excluded, one was non-verbal and a second child was unable to sit in his chair, due to severe hyperactivity.

Table 1

#### *Summary of Demographic Characteristics*

Variables	Age Group (years)						Total n
	6	7	8	9	10	11	
Gender							
Female	45	43	41	42	32	18	221
Male	46	47	38	45	32	16	224
Ethnicity <sup>1</sup>							
New Zealand European	68	71	66	68	52	25	350
Maori	11	9	6	8	6	3	43
Pacific	3	0	2	0	0	1	6
Asian	3	4	2	5	3	1	18
MELAA <sup>2</sup>	1	3	0	1	2	2	9
Other	5	3	3	5	1	2	19
<i>Total n</i>	<i>91</i>	<i>90</i>	<i>79</i>	<i>87</i>	<i>64</i>	<i>34</i>	<i>445</i>

*Note.* <sup>1</sup> Ethnicity was prioritised based on Ministry of Health codes (Ministry of Health, 2004). <sup>2</sup> = Middle Eastern/ Latin American/African

### Neuropsychological assessment

The aim of the neuropsychological assessment was to assess across the cognitive domains, using age appropriate, recent and psychometrically reliable measures that were enjoyable for the children. The measures included selective subtests of the NEPSY-II, WISC-IV and TEA-Ch. Order of test administration, as shown in Table 2 below, was determined to

ensure that no single cognitive domain was consecutively assessed, and that sufficient time was given for the delayed component.

Table 2

*Neuropsychological Assessment Administration Order*

Order	Subtest	Test name	Cognitive domain
1	Sky Search	TEA-CH	Attention
2	Memory for faces	NEPSY-II	Memory & Learning
3	Auditory attention & response set	NEPSY-II	Attention & Executive Function
4	Digit Span	WISC-IV	Working Memory
5	Narrative Memory	NEPSY-II	Verbal Memory
6	Inhibition	NEPSY-II	Attention & Executive Function
7	Finger Tapping	NEPSY-II	Motor Skills
8	Coding	WISC-IV	Information Processing Speed
9	Memory for faces - Delayed	NEPSY-II	Memory & Learning
10	Comprehension of Instructions	NEPSY-II	Language
11	Affect recognition	NEPSY-II	Social Perception
12	Theory of Mind	NEPSY-II	Social Perception
13	Animal Sorting	NEPSY-II	Executive Function

**Procedure**

Children were recruited as part of a larger study. Their parents provided consent and completed demographic questionnaires. The neuropsychological assessments occurred in 30 schools. Each school was asked to provide a quiet, comfortable space with adequate lighting in order to ensure a standardised testing environment. Children were excused from their classroom for approximately one hour during a school day to participate in the assessment. Assent was obtained from the children prior to completing the assessment and at the end of each child was offered an item (e.g., pencil or stickers) to thank them for their time.

**National Standards**

With parents' permission, National Standards for reading, writing and mathematics for each child in the study were obtained from the school principals.

## Results

### Relationships between cognitive domains

Pearson's product moment correlational analyses were conducted to investigate interrelationships between the measures of cognitive domains (Table 3). Most correlations were considered statistically significant, as indicated by asterisks. The strengths of the correlation relationships are the  $r$  values with values ranging between .100-.300 considered weak relationships, .300-.500 moderate relationships and above .500 strong relationships (Cohen, 1988). Values below .100 are considered to be very weak. Moderate to strong relationships are bolded in Table 3 in order to differentiate them from the weak and very relationships.

Table 3

*Persons correlations of the raw scores on neuropsychological measures by cognitive domain*

Subtests by domain	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
<b>Attention</b>																		
1. Sky Search+																		
2. Auditory Attention	-.20**																	
<b>Executive Function</b>																		
3. Response Set	-.21**	.49**																
4. Animal Sorting	-.30**	.27**	.20**															
5. Inhibition N	.43**	-.46**	-.34**	-.30**														
6. Inhibition I	.39**	-.40**	-.38**	-.35**	.81**													
7. Inhibition S	.33**	-.34**	-.26**	-.35**	-.70**	.73**												
<b>Memory</b>																		
8. Narrative F	-.23**	.23**	.17**	.13*	-.23**	-.28**	-.04											
9. Narrative F & C	-.21**	.19**	.17**	.09	-.23**	-.27**	-.03	.92**										
10. Memory for Faces I	-.07	.18**	.17**	.14**	-.22**	-.21**	-.13*	.16**	.14**									
11. Memory for Faces D	-.11*	.11*	.12*	.17**	-.18*	-.20**	-.16**	.15**	.10*	.46**								
<b>Social perception</b>																		
12. Theory of Mind V	-.31**	.31**	.23**	.34**	-.50**	-.47**	-.23**	.38**	.35**	.20**	.15**							
13. Theory of Mind C	-.16**	.12*	.01	.17**	-.19**	-.19**	-.10	.22**	.20**	.14**	.14**	.29**						
14. Affect Recognition	-.29**	.32**	.15**	.28**	-.45**	-.42**	-.19**	.27**	.24**	.31**	.28**	.40**	.24**					
<b>Motor Function</b>																		
15. Finger Tapping+	.30**	-.35**	-.25**	-.10	.50**	.44**	.35**	-.19**	-.17**	-.23**	-.22**	-.30**	-.18**	-.36**				
<b>Working Memory</b>																		
16. Digit Span	-.28**	.34**	.32**	.28**	-.44**	-.41**	-.23**	.22**	.21**	.20**	.14**	.40**	.19**	.31**	-.27**			
<b>Processing speed</b>																		
17. Coding	-.16**	.017	.13**	.15**	-.22**	-.16**	-.19**	-.00	.02	.09	.076	.022	.01	-.02	-.06	.18**		
<b>Language</b>																		
18. Comprehension of I	-.31**	.30**	.33**	.35**	-.45**	-.41**	-.28**	.32**	.30**	.17**	.15**	.50**	.21**	.32**	-.30**	.44**	.07	

*Note.* \* =  $p < .05$ ; \*\* =  $p < .001$ . Sky search is the overall score of attention; auditory attention and response set is overall accuracy; animal sorting is number of correct sorts; inhibition naming (N), inhibition (I) and switching (S) is completion time in seconds; narrative memory is free recall (F) and free and cued recall (F & C); Memory for faces is correct recall for immediate (I) and delayed (D); affect recognition is total raw score; theory of mind is raw score for verbal (V) and contextual (C) tasks; Finger tapping time taken in seconds; digit span total raw score; coding total raw score and comprehension of instructions (I) total correct responses.

As evident in Table 3, the majority of the relationships *between* the cognitive domains are moderate – weak. The strongest relationships were between components of the same subtest, for example Narrative Memory (free and free and cued recall) and Inhibition (naming and inhibition).

### **Neuropsychological Ability and National Standards of Achievement**

Table 4 presents the sample size for each indicator of school achievement across the three levels of the National Standards (mathematics, writing and reading); below, at or above the standard<sup>11</sup>.

Table 4

#### *Sample sizes for National Standards of achievement*

	<b>Mathematics</b>	<b>Writing</b>	<b>Reading</b>
<b>Below</b>	30 (7%*)	40 (10%)	24 (6%)
<b>At</b>	243 (59%)	262 (63%)	197 (47%)
<b>Above</b>	140 (34%)	111 (27%)	194 (47%)
<i>Total n</i>	<i>413</i>	<i>413</i>	<i>415</i>

*Note.* Fluctuations in *total n* are due to the unavailability of some National Standards data. \* = Percentages in the table have been rounded to a whole number.

The relationships between achievement and neuropsychological ability were explored over the age range 6 to 11 years using correlation analyses (see Table 5). As National Standards are an ordinal variable, Spearman rank correlation analyses were used instead of a Pearson correlation analysis. As above, moderate to strong relationships are bolded to differentiate them from the weak and not meaningful relationships.

<sup>11</sup> It is possible for children to be rated well-below the standard however, children who fell well-below of the standard were not included in the study

Table 5

*Spearman's correlations for each age group of school achievement National Standards and subtests by cognitive domain*

Subtests by domain	6-year olds n = 91			7-year olds n = 90			8-year olds n = 79			9-year olds n = 87			10-year olds n = 64			11-year olds n = 34		
	Math	Writing	Reading	Math	Writing	Reading	Math	Writing	Reading									
<b>Attention</b>																		
1. Sky Search	-.11	-.22	-.20	-.05	-.12	-.13	-.22	-.23*	-.17	-.27*	-.10	-.05	-.16	-.23	-.14	-.38*	-.16	-.35
2. Auditory Attention	.16	.21	-0.02	.24*	.20	.07	.18	.06	-.10	.06	.19	-.06	.09	.01	.10	-.11	-.11	.07
<b>Executive Function</b>																		
3. Response Set	na	Na	na	.23*	.18	.14	.22	.19	.12	.15	.06	.08	.22	.23	.06	-.15	.15	.28
4. Animal Sorting	na	Na	na	.02	.11	.12	.29*	.13	.18	.01	-.07	.03	.23	.59**	.30*	.40*	-.25	.26
5. Inhibition - N	-.17	-.37**	-.42**	-.19	-.13	-.32*	-.23*	-.09	-.13	-.24*	-.07	-.21	-.35*	-.27*	-.26*	-.21	.12	-.48*
6. Inhibition - I	-.01	-.15	-.21*	-.18	.01	-.15	-.30*	-.07	-.12	-.13	-.05	-.13	-.24	-.02	-.15	-.26	-.02	-.47*
7. Inhibition - S	Na	Na	Na	-.18	-.04	-.21	-.15	.05	-.13	-.01	-.06	-.07	-.25	-.04	-.11	-.25	.27	-.36
<b>Memory</b>																		
8. Narrative - F	-.05	.12	.11	.24*	.09	.21	.17	.27*	.18	.12	.07	.21	.13	.13	.25	.20	.02	.24
9. Narrative - F & C	-.03	.12	.12	.21	.09	.21	.17	.24*	.16	.04	.04	.20	.21	.19	.32*	.25	-.03	.22
10. Memory for Faces - I	-.04	-.05	.11	.08	.06	.14	-.01	.10	.01	.10	-.08	.12	-.06	-.24	-.05	.12	-.22	.08
11. Memory for Faces - D	-.03	-.02	.01	0.11	.03	.13	-.02	.03	.08	.04	-.01	-.12	.05	-.01	.11	.06	.02	.30
<b>Social perception</b>																		
12. Theory of Mind - V	.00	.32*	.31*	.20	.15	.19	.42**	.26*	.15	.33*	.02	.30*	.31*	.31*	.31*	.25	.03	.42*
13. Theory of Mind - C	-.06	.07	.10	.26*	.06	.05	.27*	.22*	.28*	.11	.07	.18	.27*	.38*	.29*	.13	.30	.25
14. Affect Recognition	.02	.17	.13	-.02	.02	.01	-.00	.07	.03	.03	-.03	-.01	-.11	.02	-.14	.17	.22	.44*
<b>Motor Function</b>																		
15. Finger Tapping	.10	.03	.01	-.05	-.07	-.05	-.18	-.01	-.11	-.12	-.02	-.02	.17	.03	-.13	-.09	-.03	-.35
<b>Working Memory</b>																		
16. Digit Span	.28*	.46**	.49**	.24*	.32*	.15	.24*	.22*	.06	.16	-.12	.04	.46**	.29*	.20	.34	.34	.54*
<b>Processing speed</b>																		
17. Coding	-.04	.19	.19	.09	.25*	.06	.27*	.21*	.18	.35**	.23*	.25*	.28*	.28*	.21	.15	.06	.41*
<b>Language</b>																		
18. Comprehension of I	.11	.33*	.33*	.10	.18	.13	.24*	.16	.20	.45**	.24*	.29*	.43**	.50**	.42**	.24	.31	.32

*Note.* \* =  $p < .05$ ; \*\* =  $p < .001$ . Sky search is the overall score of attention; auditory attention and response set is overall accuracy; animal sorting is number of correct sorts; inhibition naming (N), inhibition (I) and switching (S) is completion time in seconds; narrative memory is free recall (F) and free and cued recall (F & C); Memory for faces is correct recall for immediate (I) and delayed (D); affect recognition is total raw score; theory of mind is raw score for verbal (V) and contextual (C) tasks; Finger tapping time taken in seconds; digit span total raw score; coding total raw score and comprehension of instructions (I) total correct responses.

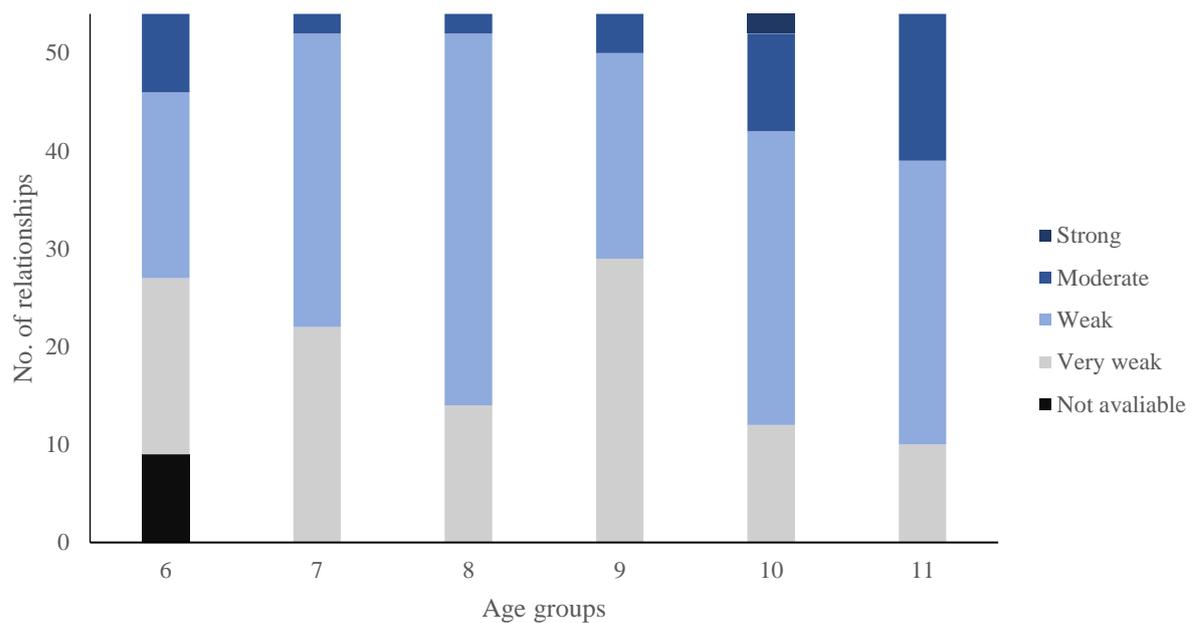
The results presented in Table 5 indicate the significance and size of the relationships between neuropsychological abilities and national standard achievement in reading, writing and mathematics varies across the age groups.

The measures of ability with the most significant relationships with National Standard achievement across the age groups were, working memory (digit span on WISC-IV) and social perception (theory of mind verbal task on NEPSY-II), followed by processing speed (coding on WISC-IV), executive functioning (inhibition naming on NEPSY-II) and language (comprehension of instructions on NEPSY-II).

Non-significant relationships were found with three measures of ability assessing memory (memory for faces immediate and delayed) and motor skills (finger tapping on NEPSY-II) and all three measures of National Standard achievement across all age groups.

As seen in Table 5, intra-domain variability was present in cognitive domains with multiple measures, particularly executive functioning and social perception. It is evident that National Standard achievement is more strongly related to some aspects of executive functioning (inhibition and sorting) than others (response set and switching). This is also true for aspects of social perception, with National Standards having a stronger relationship with theory of mind verbal than affect recognition.

The number of strong, moderate, weak and very weak relationships between cognitive abilities and National Standards for each age group is depicted in *Figure 1* for greater clarity of the variation observed across each age group.



**Figure 1.** Strength of relationships across the age groups between neuropsychological ability and National Standards

*Note.* The total number of relationships for each age group is 54 (18 measures of ability x 3 National Standard ratings) is presented on the y axis. As mentioned, r values below .100 are very weak relationships, values between .100-.300 are weak, .300-.500 moderate and above .500 are strong relationships (Cohen, 1988). As response set, animal sorting and inhibition switching are only administered for children aged 7+, this information is not available for the 6-year-old age group.

As is evident in Figure , 6, 10 and 11-year-old groups have the most moderate relationships between National Standards and cognitive ability. Two strong relationships were found in the 10-year-old group. The majority of the relationships in the 9-year-old group were very weak.

### Discussion

The aim of the current research was to explore the relationship between neuropsychological ability and National Standards of achievement in New Zealand children aged 6 to 11 years.

As expected, the correlations between neuropsychological abilities were consistent with the literature. The significant correlations observed between motor skills (measured by finger tapping on the NEPSY-II) and measures of attention, executive function, theory of mind and affect recognition are congruent with a recent review in the literature noting the relationship between motor and cognitive skills (van der Fels et al., 2015). Strong correlations were also observed, within components of the same subtest (e.g., inhibition and narrative memory) and moderate correlations within the same cognitive ability (e.g., animal sorting and inhibition-switching).

Secondly, the findings of the correlation analyses between neuropsychological abilities and the national standards partially supported the hypotheses. The abilities with the most significant relationships with school achievement were social perception (theory of mind verbal task on NEPSY-II) and working memory (digit span on WISC-IV), followed by processing speed (coding on WISC-IV), executive functioning (inhibition naming on NEPSY-II) and language (comprehension of instructions on NEPSY-II) which is congruent with the hypothesis of the study and with the literature (Alloway & Alloway, 2009; Bull, 2009; Cameron et al., 2016; Christopher et al., 2016; Holmes & Adams, 2006; Passolunghi & Lanfranchi, 2012; Son & Meisels, 2006; St Clair-Thompson & Gathercole, 2006; Susana et al., 2015; Willoughby et al., 2012)

However, no significant relationship was found between school achievement and three neuropsychological measures from the NEPSY-II; finger tapping, inhibition switching, and memory for faces. The finding of no significant relationship between motor skills and academic achievement is incongruent with literature (Dinehart & Manfra, 2013; Geertsen et al., 2016; Son & Meisels, 2006). This may be due to the measure of motor skill (finger tapping NEPSY-II) only assessing fine motor function, where as some of the previous literature also included measures for visual and gross motor skills (Geertsen et al., 2016; Son

& Meisels, 2006). It was also unexpected that inhibition switching would be insignificant, however further review of the literature found switching has had inconsistent findings (Yeniad et al., 2013). va der Sluis, Jong, and Leij, (2007) for example found an insignificant relationship between switching and mathematics, explaining that components of mathematics may require switching ability, however the role is minimal (va der Sluis et al., 2007). It is therefore likely that significant relationships are dependent on how the specific academic skills are being assessed.

In regard to memory for faces and academic achievement, literature on this relationship is minimal. Information that is available from the NEPSY-II manual (Korkman et al., 2007), reports correlations with the WIAT-II for memory for faces immediate to range from  $r = -.07$  to  $.20$  and memory for faces delayed to range from  $r = -.03$  to  $.14$  (Korkman et al., 2007). The NEPSY-II manual does not report the significance of the correlations. These weak relationships reported in the NEPSY-II manual are congruent with the findings of the current study.

There was intra-domain variability in the strength of the relationship with National Standards, most frequently with the measures of executive functioning and social perception. As executive functioning is composed of separate inter-related constructs (Best, Miller, & Jones, 2009), variability between measures of executive functioning is not surprising. With regards to the intra-domain variability observed for social perception, theory of mind was found to be more significant and more strongly related to achievement than affect recognition. This could be explained by the earlier correlations in this study, with theory of mind having stronger relationships with other neuropsychological abilities than affect recognition (see Table 3). It is possible the strength of the relationship between theory of

mind and executive functioning, may explain why theory of mind was more strongly connected to achievement than affect recognition.

The strongest overall correlation was between executive function, measured by animal sorting (NEPSY-II) and writing in 10-year-old children (.59\*\*). This may be due to the writing standards for 10-year-old children requiring executive functioning. However, inhibition switching which also assesses executive functioning, was not strongly or significantly related to writing in 10-year-old children (-.04). Therefore, this finding may be explained by writing standards at age 10 requiring specific skills in concept formation which are assessed in the animal sorting task and not in other measures of executive functioning. The NEPSY-II manual reports an overall correlation between animal sorting and WIAT-II Written language to be .35, which supports the theory that our finding is most likely due to the underlying ability of concept formation required for writing at age 10.

The only other strong relationship was found between writing standards and comprehension of instructions (NEPSY-II) in 10-year-old children (.50\*\*). This strong relationship was noted in the NEPSY-II manual comparison with the WIAT-II, with a strong relationship of  $r = .53$  found comprehension of instructions and written expression (WIAT-II) (Korkman et al., 2007).

Finally, the relationships observed across the age groups indicate that ages 6, 10 and 11 years are the periods of middle childhood with the strongest relationships between neuropsychological ability and National Standard achievement. At age 7, 8 and 9 years, this relationship is weaker, suggesting performance on either neuropsychological test or National Standards, is not reflective of performance on the other. An implication of this finding maybe that a child performing low on National Standards age 7 to 9, does not mean that their cognitive abilities are also poor.

A limitation in the current study is task impurity (the challenge to assess a single ability by one task) which is documented in the literature in this area (Cantin et al., 2016). To minimise this effect, future research in this area could include multiple measures of all cognitive domains which will provide greater depth to this area of research. In addition to this, including both academic performance as measured in schools as well as standardised achievement measures will also enhance future research. Due to the use of National Standards in this study caution should be taken in generalising the findings to other measures of school achievement. Finally, it is also acknowledged that there are concerns regarding the use of National Standards as they are controversial and debated in the literature (Bonne, 2016; Özerk & Whitehead, 2012; Thrupp, 2013).

In conclusion, this study was the first to explore relationships between cognitive abilities and National Standards of achievement during development with New Zealand children. Overall, the majority of the findings were consistent with previous literature on relationships between neuropsychological abilities and academic achievement, with finger tapping and memory for faces the two exceptions. Age patterns in the relationships between neuropsychological abilities and academic achievement were found to be strongest at age 6, 10 and 11 years and weakest at 7, 8 and 9 years. These findings contribute to the literature on the relationships between neuropsychological development and achievement in typically developing children.

The following page presents Study 3 as a research manuscript. This Chapter is published in the *New Zealand Journal of Psychology* and therefore is written in the format style required for this submission.

Ross-McAlpine, K., Leathem, J., & Flett, R. (2018). A survey of psychologists administering cognitive and neuropsychological assessments with New Zealand children. *New Zealand Journal of Psychology*, *47*(1), 13-22.

## CHAPTER TEN: GENERAL DISCUSSION

This chapter will provide a general discussion and the conclusion for the thesis. The research findings from each research study have been discussed previously in Chapters 7, 8 and 9, however this chapter will provide an integrated overview of the findings. The contributions of this research to the existing literature and clinical implications will be outlined. The research limitations, recommendations for future research and challenges of conducting research will be provided.

### Overview of the Research Findings

Study 1 explored the age effects in neuropsychological measures for typically developing children aged 6 to 11 years. Scaled scores of the NZ sample were within  $\pm 0.4$  of a standard deviation standard score of the overseas normative groups for all tests except for finger tapping and animal sorting (NEPSY-II). NZ children almost performed one standard deviation higher than the US standardisation group on finger tapping ( $M = 12.99$ ). Administrator effect was initially considered to explain this finding however, the effect was determined to be minimal on the scaled scores. The time between the collection of the USA normative group in 2007, compared with the current studies data collection during 2015-2016 may partly explain the different result, as during this period children have been slowly exposed to more and more technologies and devices that require fine motor dexterity (e.g., hand held devices, computers, smart phones and tablets). In the media, paediatric occupational therapists have expressed their concern with children's fine motor skills by excess use of technologies (Hill, 2018), however empirical research is limited. The finding that New Zealand children performed lower on animal sorting ( $M = 8.21$ ) could possibly be explained by test administration effects, as animal sorting

was the final test to be administered to each child however, it is not clear why this result was found. Initially, it seems New Zealand normative data would be beneficial for only these two subtests (finger tapping and animal sorting). However, as mentioned in the discussion of Chapter 7, it seems likely that more differences do exist, but went unnoticed due to the under-representation of ethnic minority groups in our sample <sup>18</sup>.

Study 1 also found age effects for all measures of cognitive abilities and post-hoc findings identified that the most significant improvement occurred between ages 6 and 9 years. These findings confirm previous literature in USA and Europe (Korkman et al., 2013; Mous et al., 2017; Rosenqvist et al., 2017).

Study 2 investigated the relationships between cognitive domains and school achievement in typically developing New Zealand children. Correlation analyses found the majority of the relationships between the cognitive domains to be moderate – weak. The findings were mixed in regards to the hypotheses on relationships between neuropsychological ability and school achievement. The abilities with the most significant relationships with school achievement were social perception (theory of mind verbal task on NEPSY-II) and working memory (digit span on WISC-IV), followed by processing speed (coding on WISC-IV), executive functioning (inhibition naming on NEPSY-II) and language (comprehension of instructions on NEPSY-II) which is congruent with the hypothesis of the study and with the literature (Alloway & Alloway, 2009; Bull, 2009; Cameron et al., 2016; Christopher et al., 2016; Holmes & Adams, 2006; Passolunghi & Lanfranchi, 2012; Son & Meisels, 2006; St Clair-Thompson & Gathercole, 2006; Susana et al., 2015; Willoughby et al., 2012). However, a non-

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<sup>18</sup> The representation of the sample is discussed in more depth as a research limitation later in this chapter

significant relationship was found between motor skills and academic achievement which is incongruent with literature (Dinehart & Manfra, 2013; Geertsen et al., 2016; Son & Meisels, 2006). Investigating this relationship across age groups revealed that ages 6, 10 and 11 years are the periods of middle childhood with the strongest relationships between neuropsychological ability and National Standard achievement. This suggests that at 7, 8 and 9 years, performance on either neuropsychological tests or national standards, is not reflective of performance on the other.

Study 3 was a survey of psychologists administering cognitive and neuropsychological assessments with New Zealand children. This study sought to explore current practices of neuropsychological assessment with children. It was found that the WISC-IV was the most commonly used comprehensive measure to assess cognitive and neuropsychological function of New Zealand children. The most frequently used measure was the WISC-IV, which demonstrates the reliance on intelligence measures in cognitive and neuropsychological assessments in New Zealand. This finding highlights the relevance of the debate discussed in Chapter Two, on the use of intelligence tests in neuropsychological assessments. However, it is also possible that it could be explained by the assessment of intellectual disability which requires an assessment of intelligence. Congruent with this, is the finding that behaviour ratings scales were used frequently, with the most commonly used domain specific/rating scales being the ABAS, CBCL and CCBRS. The results of the survey indicated that test selection appears dominated by pragmatic considerations such as lack of familiarity and access. The focus on the diversity of New Zealand was reflected in the finding that the majority of the survey respondents considered it to be important to obtain normative data for New Zealand children (80.3%).

## **Integration of Research Findings**

The research findings and contributions to the literature for the three research studies can be presented individually, as outlined above. However, the following section presents integrations when the research studies are considered together.

Both Study 1 and 2 establish typical patterns of development for children ages 6 to 11, for neuropsychological abilities (Study 1) and how these relate to school achievement (Study 2). An interesting finding for the age period 6 to 9 years was revealed when these two studies were considered together. It was found that during this period the most rapid development of neuropsychological ability occurs (Study 1) and from 7 to 9 years the weakest relationships with National Standards of achievement were found (Study 2). It is possible this is due to the variance occurring in neuropsychological ability scores from ages 6 to 9.

Another integration of the research findings is on the topic of normative data. Specifically, regarding the need for normative data for New Zealand children on neuropsychological assessment measures. Firstly, Study 1 found two subtests to differ between the New Zealand sample of children and children from the USA. As discussed above, the under-representation of ethnic minority groups, it seems likely that more differences do exist but went unnoticed. Secondly, Study 3 found majority (80.3%) of psychologists surveyed responded yes when asked if they felt NZ normative data was needed. When considering the findings from Study 1 and 3 together, as well as the recent New Zealand literature on cross-cultural neuropsychology (Dudley et al., 2016) and Maori and neuropsychological assessment (Dudley, 2016) there is an argument for obtaining normative data for New Zealand.

## Contributions to Existing Literature

The three research studies in this thesis provide modest contributions to the literature in the areas of neuropsychological development, assessment and cross-cultural neuropsychology. These contributions are discussed below for each Study.

The research in Study 1 provides further evidence of the age effects in neuropsychological abilities during development 6 to 11 years. The findings confirm the previous literature on age effects, including evidence of rapid development for children ages 6 to 9 years (Korkman et al., 2001, 2013; Mous et al., 2017; Rosenqvist et al., 2017). Furthermore, research on age effects had not been confirmed outside of USA and Europe. The comparison in Study 1 of New Zealand children with overseas normative groups contributes to cross-cultural neuropsychological literature. As New Zealand normative data on neuropsychological measures for children is limited, the comparisons between normed groups is vital to ensure accurate assessments. Overall, this study provides greater confidence in determining the patterns of age in typical neuropsychological development with a New Zealand sample.

Study 2 provides a unique contribution to the literature by exploring the relationships between neuropsychological abilities and academic achievement during development across age groups. Firstly, this study explored the relationships between cognitive domains, which expanded previous literature by investigating *multiple* cognitive domains with a larger sample size. Secondly, this study was the first to investigate relationships between cognitive abilities and National Standards of achievement across age groups, providing a unique contribution to the literature.

The most important contribution of Study 3 to the literature is that it provides the frequency of use of measures for cognitive and neuropsychological assessment with children in New Zealand. This contribution is unique as this information did not previously exist. In addition to this, psychologists administering these measures provided their perspectives on reasons for test selection and their opinions on cultural considerations to assessments, which is unique in the literature. Overall, this study provided clarity regarding current practices in neuropsychological assessment and investigated opinions regarding culturally appropriate neuropsychological assessment in New Zealand.

### **Clinical Implications**

The current research has clinical implications for neuropsychological practice with New Zealand children. These are discussed below.

Firstly, this research has implications for clinicians administering cognitive and neuropsychological assessments with New Zealand children. It has been discussed in the literature that inaccurate neuropsychological assessments can have high stake consequences, some of which can lead to academic, behavioural and social repercussions for the child (Williams, Sando, & Soles, 2014). Findings from Study 1 and Study 3 have implications for the accuracy of administration, current assessment practices and interpretation of test scores. The comparisons between New Zealand children and overseas normative groups presented in Study 1, indicate that New Zealand children perform differently in some subtests than overseas normative groups. Practically, this could indicate that a child's poor performance may indicate a population level difference, not an individual difference. Study 3 has clinical implications for a neuropsychologist in New Zealand as it provides an overview of their colleagues' practices. Specifically, the use of different psychometric measures and practical adaptations which are

made when administering measures with New Zealand children has clinical benefit. Overall, these findings should contribute to increased consideration in both administration and interpretation of test scores for New Zealand.

Secondly, the research presented in Study 1 and 2, as with all research on typically developing children, provides an overview of expected patterns and relationships in neuropsychological development. This has clinical implications when conceptualising a child's performance, as having a comprehensive understanding of typical neuropsychological patterns and relationships, allows for easier identification of atypical performance patterns. Subsequently this leads to understanding the consequences and influence of atypical performance on other factors, such as on other neuropsychological abilities and on National Standards of achievement.

Thirdly, the finding that the relationship between performance on neuropsychological ability and national standards varies depending on the age of the child, has clinical implications. For example, if a child is performing poorly in National Standards age 7 to 9, then this may not be representative of their cognitive abilities. This perhaps indicates the importance of other contextual and environmental factors that may be influencing a child's performance at that time.

Finally, an interesting commonality was found between a comment from a survey participant in Study 3 and researcher observation during Studies 1 and 2 regarding Story B from the subtest Narrative Memory from the NEPSY-II. Story B is administered to children 11 years and older. A survey respondent in Study 3 commented "*Narrative memory has a story that is far too complex for most teens and adults!*", which was congruent with research observations and discussed by the four researchers involved in the neuropsychological assessments. Furthermore, when the researcher commented on this observation when Study 1 was presented at the INS

Conference (see Appendix H), a neuropsychologist in the audience expressed their agreement with this. This finding, noted from three sources strongly indicates that Narrative Memory Story B is inappropriately difficult, which has clinical relevance for neuropsychologists administering this subtest.

## **Research Limitations**

Research limitations need be considered when interpreting the findings. The three research studies have limitations which will be discussed below, some of which may have been discussed in the previous three chapters. Firstly, due their methodology being the same the research limitations for Study 1 and 2 will be discussed, followed by the limitations of Study 3.

### **Study 1 and 2**

**Response rate.** As discussed in Chapter 6, the initial overall response rate was low (11%) and the response rate from lower decile schools was significantly lower than higher decile schools (see *Figure 3* in Chapter 6). As mentioned, numerous attempts were made to increase response rate. The final overall response rate of 13% is considered low and indicates concern with external validity. This limitation of the current study is acknowledged.

**Testing environment.** Despite the best intentions for schools to provide an adequate space for an assessment, some of the assessments took place in a variety of locations around a school. These locations included; empty classrooms, libraries, staff rooms and resource rooms. On occasion, it meant there were a variety of distractions and interruptions. An example of this is administering an assessment in a staff room with staff coming and going to use a photocopier. While this environment is less than ideal, given the context of conducting research within a school environment and schools having limited space, there was no feasible alternative.

*The Sample.* There were differences between the current sample and overseas normative samples, for example the variation in total sample size (NEPSY-II  $n = 1,200$ , WISC-IV  $n = 851$  and current study  $n = 450$ ) and age range (NEPSY-II 3-16 years and WISC-IV 6-16 years and current study 6-11 years). These differences between compared groups is recognized as a research limitation. The results must be considered in light of these differences.

The sample of children had a skewed representation of age, with 11-year olds least represented. One reason for this may have been due to the time between recruitment and administering the neuropsychological assessments, due to the nature of the larger study, the longest time period between recruitment and administration could be up to a year. Children may have been 11 years old at recruitment but turned 12 before the neuropsychological assessment was administered or children could have moved from Primary School to Intermediate School.

There was also an over-representation of New Zealand European, MELAA and other children in the sample, as well as an under-representation of lower decile schools. This impacts the generalisability of the results. The over-representativeness of New Zealand European children in the sample and poorer representation from ethnic minority groups (specifically Maori, Pacific Island and Asian children) may have resulted in differences for these minority groups going undetected. In particular, the differences between samples on only two tasks in Study 1 (finger tapping and animal sorting), may be due to the over-representation of New Zealand European children. It is possible further differences would have been found with a greater representation of indigenous and minority groups in the sample.

It is also acknowledged that participation was determined by the parent's decision to take part in the study. Parents concerned about pesticides and those who are willing and able to

complete the long Phase I questionnaire, are likely factors in the decision to participate. These contributing factors influencing participation are a research limitation and likely affected the representativeness of the sample.

Finally, it must also be acknowledged that these four regions are not necessarily representative of the population of New Zealand children.

***Test Administration.*** As the same order of test administration was used for every child, order effects may have possibly impacted on performance. As mentioned above, the final subtest administered, animal sorting was found to be lower than overseas norms in Study 1. It is possible children may have been fatigued or lost interest by the final test leading to poorer overall performance. Randomising the order of test administration would have eliminated the possibility of order effects on performance.

The preliminary finding of an administrator effect on finger tapping was considered as a limitation, as ideally this would have been identified and rectified early during data collection. However, when explored in depth this research limitation is minor. This effect was considered and discussed in Study 1, as it was found that New Zealand children performed nearly one standard deviation higher than overseas norms ( $M = 12.99$ ). As outlined in Chapter 7, the effect was determined by calculating the weighted mean scaled scores without researcher 2. This was found to be  $M = 12.96$ , only 0.03 less than when researcher 2 was included ( $M = 12.99$ ). It was concluded that the administrator effect could not account for the finding of New Zealand children performing better than overseas normative groups and was better explained by other factors (e.g. effect of technology use and US culture). Overall, when converted into scaled scores, researcher 2 had a minimal effect on the overall scaled scores, despite recording more

children completing the task in 4 seconds (i.e., at a quicker rate) compared to the other researchers. This research limitation, although minor, ideally would have been corrected earlier.

***Measure of Achievement.*** The use of National Standards as the measure of school achievement in Study 2 could be considered a research limitation for three reasons. Firstly, the literature is somewhat divided on the best way to assess school performance with Roth et al., (2015) stating that school grades can be seen as a more direct measure of scholastic success than standardised achievement tests. One research study with university students in the USA previously discussed used both standardised assessment measure (such as the WRAT or WIAT) as well as University SAT scores (Rohde & Thompson, 2007). Although it was not feasible in the current study, it would have been beneficial to also have included a standardised objective psychometric measure of achievement. As found in Study 3, the most frequently used measure of achievement in New Zealand was the WIAT-3.

Secondly, it also important to note that the use of National Standards is debated in the education literature (Bonne, 2016; Özerk & Whitehead, 2012). Further, during our data collection school teachers and one school principal voiced their concern that information from the National Standards, (which they considered an unreliable and subjective measure of school achievement) was being used in the research.

Finally, in late 2017 during the writing of this thesis the New Zealand Government removed compulsory reporting of National Standards. Therefore, the way in which primary schools assess achievement is in a state of change. As such, caution should be taken in generalising the findings to other measures of school achievement.

Despite these limitations, due to the nature of this research the National Standards were the most appropriate measure of achievement for the current research.

### **Study 3**

As mentioned in Chapter 9, a limitation of Study 3 is the sample which was self-selective in nature due to the recruitment process. This may have resulted in sample biases. It is acknowledged that this impacts the generalizability of the study findings.

### **Recommendations for future research**

Based on the findings from the three research studies in this thesis, several recommendations for future research are made.

Normative data would be beneficial for a range of psychometric measures to accurately represent all New Zealand children. As discussed above, this was expressed with the majority of psychologists surveyed working in this area, as well as differences detected between New Zealand and overseas norms. It is also necessary to acknowledge that possible additional differences would have been found if our sample in Study 1 was more representative of minority groups within New Zealand. It is recommended that the most frequently used measures are prioritised for developing New Zealand norms. From the findings of Study 3 this indicates the priority should be for comprehensive measures such as the NEPSY-II and informant/domain measures such as the ABAS-3, Conners CBRS and CBCL. As mentioned in Chapter 9, the author is aware normative data has been collected for the WISC-V and WIPPSI-IV with a sample of 528 children from New Zealand and Australia.

Due to the over-representation of New Zealand European children in Study 1 and 2, future research should investigate developmental patterns in minority cultures in New Zealand.

Research in neuropsychological development research should also investigate underlying factors influencing rapid development observed in children age 6 to 9 years. Research exploring developmental trends by including multiple measures of multi-faceted abilities, specifically executive functioning, will provide more thorough understanding of neuropsychological development in childhood. Likewise, research exploring relationships between neuropsychology ability and academic including both school grades as well as standardised achievement measure would be beneficial.

Finally, exploring the findings in Studies 1 and 2 with children who have atypical development would be beneficial. Specifically, exploring the patterns of performance across ages 6 to 11 years and relationships between other abilities and achievement with different clinical groups would be of value. It would be important to consider performance with atypical children at different ages. Understanding the nature of these relationships also has the potential to aid interventions for individuals with atypical development.

### **Challenges of Conducting Research**

Administering neuropsychological assessments in primary schools, designing a research survey and working with young children provided different challenges which are discussed below.

**Working with Schools.** The context of administering the assessments in primary schools provided a number of challenges to the data collection process all of which are part of the reality of working with schools. As we aimed to complete each assessment in one uninterrupted session, forward planning was critical to minimise disruptions as each school had a different timetable (e.g., for morning tea and lunch times). Efficient use of time was important due to the long-

distance travel required by the researchers for data collection and the restriction of administering the assessments within school hours. However, interruptions during data collection occurred on both an individual and classroom level. Examples of this on a classroom level included arriving at a school, to be told that three classes would be away at a cross-country event. On an individual level, examples included going to collect a child from class and being told they were at a guitar lesson or away sick. Despite our planning and organisation, these interruptions occurred frequently, requiring patience and flexibility.

**Constructing a research survey.** The survey developed in Study 3 underwent several versions over a number of months in order to make it thorough as well as user friendly. Constructing a survey asking about test selection was difficult as we were aware of not wanting to be judgemental or place any expectations on test use or opinions regarding cultural considerations. This required repeated editing of questions and consultation with colleagues. Despite the number of revisions and consultation, the final version had an incorrect subtest included in the WISC-IV section, which was identified by a participant.

**Young children.** There was an exceptional range of maturity and behaviour observed with the children assessed. Personally, I experienced the absolute joy of working with children, their honesty as well as being challenged by a few incidences of disruptive behaviour. On one occasion I started to assess a child who was unable to sit on his chair and kept running around the room. It became apparent my assessment would be invalid because of his level of hyperactivity. During the lunch break, the teacher informed me he had recently been diagnosed with ADHD. As this diagnosis was recent, this had not been included in the questionnaire at Phase I. If it had been included, he wouldn't have been selected for neuropsychological assessment as part of our exclusion criteria. I found this experience both valuable and

challenging. Another memorable moment was when explaining the process of the assessment to a young boy, I asked whether his mum or dad has told him about the research. He replied, “*Mum said I was helping to make the world a better place*”.<sup>19</sup>

## **Conclusion**

In conclusion, the aim of this thesis was to explore aspects of neuropsychological development and assessment in New Zealand children. This was achieved using three research studies examining; age effects of neuropsychological development, the relationships between neuropsychological abilities and academic achievement and a survey of psychologists administering neuropsychological assessments with children. The findings have added to the existing literature and have clinical implications for neuropsychological development and assessment with New Zealand children. It is hoped that firstly, through clearly outlined patterns of performance by typically developing children these findings allow identification of atypical patterns and relationships during neuropsychological development. Secondly, it is hoped that ultimately through determining current practices, adaptations in administration and cultural considerations, the accuracy of neuropsychological assessment with children in New Zealand is increased.

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<sup>19</sup> Additional self-reflections on conducting research can be found in Appendix G: A Research Case Study

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## Appendix A: Statement of Contribution



MASSEY UNIVERSITY  
GRADUATE RESEARCH SCHOOL

### STATEMENT OF CONTRIBUTION TO DOCTORAL THESIS CONTAINING PUBLICATIONS

(To appear at the end of each thesis chapter/section/appendix submitted as an article/paper or collected as an appendix at the end of the thesis)

We, the candidate and the candidate's Principal Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

**Name of Candidate:** Kate Ross-McAlpine

**Name/Title of Principal Supervisor:** Professor Janet Leathem

**Name of Published Research Output and full reference:**

Ross-McAlpine, K., Leathem, J., & Flett, R. (2018) A survey of psychologists administering cognitive and neuropsychological assessments with New Zealand children. *New Zealand Journal of Psychology*, 47(1), 13-22

**In which Chapter is the Published Work:** Chapter 9

Please indicate either:

- The percentage of the Published Work that was contributed by the candidate:  
and / or
- Describe the contribution that the candidate has made to the Published Work:

The candidate was the primary researcher for this publication. Along with the support of her supervisor, the candidate generated the research questions, designed the research survey, analysed the data and completed the write up.

Kate Ross-  
McAlpine

Digitally signed by Kate Ross-  
McAlpine  
Date: 2018.04.27 14:18:24 +12'00'

Candidate's Signature

27/4/2018

Date

Janet Leathem

Digitally signed by Janet Leathem  
Date: 2018.05.01 14:28:48 +12'00'

Principal Supervisor's signature

1.5.2018

Date

## Appendix B: CPHR recruitment presentation<sup>20</sup>



Amanda Eng



Kate Ross



Yanis Brinkmann



Jean Feary



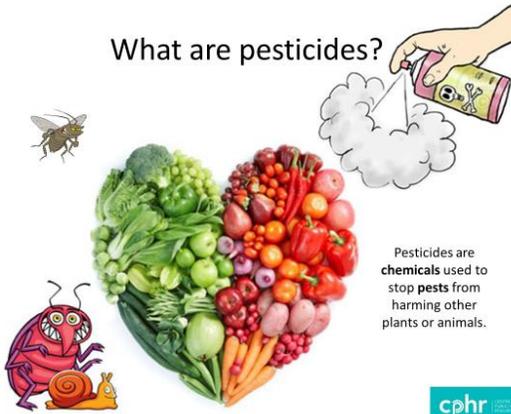
### Pesticide Exposure and Brain Function in NZ Children



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<sup>20</sup> This was presented to primary school children in school assemblies

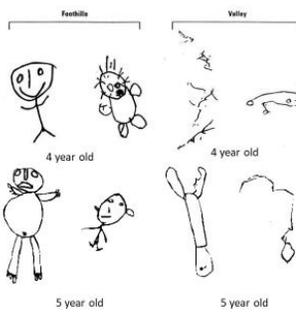
## What are pesticides?



## Where do pesticides come from?



## The effects of pesticides on the brain

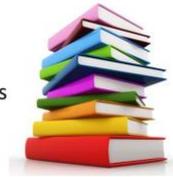


Guillette, Elizabeth, et al. EHP 106, n. 6, June, 1998



## The Study

- Questionnaires for you and your parents to fill out
  - Less than 1 hour
- May be some further testing
  - Memory and recognition games



We need your help!

You and your parents can:

- Contact us- our contact details are provided on your information pack



## Appendix C: CPHR Parent Information Sheet



### Pesticide exposure and brain function in children

## Parent Information Sheet

#### What is this study about?

We are inviting you and your child to take part in a study looking at how much children are exposed to pesticides and whether this exposure has any effects on their brain development.

There is some concern that exposure to pesticides may affect brain function and behaviour. These effects have been found in exposed farmers and farm workers, but children may also be at risk due to the use of pesticides in the home, living close to pesticide-treated farming areas, the occupation of the parents, and to a lesser extent, through the food supply and drinking water.

This study aims to assess the level of exposure to pesticides in New Zealand children and whether this exposure has any effects on the brain and mental functions, and behaviours. To do this, we are inviting 900 children aged 5-11 years to take part in this study.

#### What would participation in this study involve for me?

##### Phase I: *All participants*

Your participation will involve completing three postal questionnaires on behalf of your child. The first questionnaire will ask questions about your work history, your use of pesticides, your child's diet, and your family's health. The other two questionnaires will ask questions about your child's behaviour. All three questionnaires should take no more than about 1 hour to complete. If you are interested in taking part in the study, please complete the enclosed consent form and return it to us in the freepost envelope provided. If you agree to participate, we may also ask your child's teacher to complete the two behavioural questionnaires so that we have information about your child's behaviour at school. With your permission, we will also ask your child's school to provide us with some measures of your child's academic achievements including whether they are meeting the National Standards for reading, writing, and mathematics.

If you are *not* interested in taking part, please return the consent form indicating your refusal.

#### Centre for Public Health Research

**Massey University - Wellington Campus** PO Box 756  
Wellington, 6140 New Zealand

**Administration**  
+64 (0)4 380 0602

**Direct Fax**  
+64 (0)4 380 0600

**Courier Address**  
Block 3, Level D  
Entrance B, Wallace Street  
Wellington, 6021  
New Zealand

**Internet**  
[publichealth.massey.ac.nz](http://publichealth.massey.ac.nz)

Jean Feary Mckenzie

**Telephone**  
+64 4 979 3109  
0800 990 053

**Email**  
[j.fearymckenzie@massey.ac.nz](mailto:j.fearymckenzie@massey.ac.nz)

**For selected participants:**

**Phase II: Selected participants**

Later we will contact half (randomly chosen) of the children/parents again and ask the children to undergo neuropsychological tests of memory, attention and reaction time, as well as their language skills and visual processing skills. Tests will normally take place at school (but they can be done in your home if you prefer) and will be conducted by a trained researcher. The tests can be completed in less than an hour. Our research nurse will also ask your child to collect urine samples during and outside the spraying season and will ask you to collect a house dust sample. The collection of these samples will be used to examine pesticide exposure and will be fully explained by our research nurse.

**What will happen with my personal information?**

**We will treat all of the information from the questionnaires and the information from the school about your child as strictly confidential.** Each questionnaire and the results of the other tests will be entered into a database using ID numbers. The questionnaires and tests will be seen by named researchers only and when the study is completed all questionnaires will be locked away in filing cabinets which will be the responsibility of the Director of the Centre for Public Health Research. When the study has been completed, we will analyse the information, e.g. compare the prevalence of the effects on the brain and mental functions and behaviours in those who are exposed to pesticides compared with those who are not exposed. At the end of the study the urine and house dust samples may be tested for different chemicals related to this research. The results of the study will be published in scientific journals and a summary of the results will be provided to all study participants that have requested it. **No individual information or names will be published.**

This project has been reviewed and approved by the Central Health and Disability Ethics Committee (application ref 13/CEN/134). If you have any concerns about the conduct of this research, please contact 0800 4 ETHICS (438 442).

**You have the right to:**

- decline to participate
- decline to answer any of the questions
- withdraw from the study or parts of the study at any time
- be given access to a summary of the study findings when it is completed

Please contact us at the Centre for Public Health Research to discuss any queries or concerns about the study.

*Thank you very much for your time in considering this study.*

## Appendix D: Survey Ethics Approval



Date: 08 December 2015

Dear Kate Ross-McAlpine

Re: Ethics Notification - **4000015338** - **A SURVEY OF CLINICAL PSYCHOLOGISTS ADMINISTERING COGNITIVE AND NEUROPSYCHOLOGICAL ASSESMENTS OF NEW ZEALAND CHILDREN AGED 6 – 11 YEARS**

**This application is for an online survey as part of a Doctorate in Clinical Psychology thesis. The online survey will be completed by clinical psychologists in New Zealand who complete cognitive or neuropsychological assessments with children.**

Thank you for your notification which you have assessed as Low Risk.

Your project has been recorded in our system which is reported in the Annual Report of the Massey University Human Ethics Committee.

The low risk notification for this project is valid for a maximum of three years.

If situations subsequently occur which cause you to reconsider your ethical analysis, please go to <http://rims.massey.ac.nz> and register the changes in order that they be assessed as safe to proceed.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course -Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

**A reminder to include the following statement on all public documents:**

*"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research.*

*If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Dr Brian Finch, Director - Ethics, telephone 06 3569099 ext 86015, email [humanethics@massey.ac.nz](mailto:humanethics@massey.ac.nz).*

Please note, if a sponsoring organisation, funding authority or a journal in which you wish to publish requires evidence of committee approval (with an approval number), you will have to complete the application form again, answering "yes" to the publication question to provide more information for one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

Yours sincerely



Dr Brian Finch  
Chair, Human Ethics Chairs' Committee and Director (Research Ethics)

## Appendix E: Survey Recruitment Advertisement

A survey of Psychologists conducting cognitive and neuropsychological assessments with  
New Zealand children

Kia ora kou tou

My name is Kate Ross-McAlpine and as part of my DClinPsych research I am investigating aspects of neuropsychological assessment with New Zealand children.

I am currently seeking **psychologists who administer cognitive and neuropsychological assessments with children as part of their practice**, to complete – an online survey which will ask about use of specific measures and your professional opinions in regards to the cultural context of assessing children in New Zealand.

All survey responses will be kept completely anonymous.

The project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researchers named in this document are responsible for the ethical conduct of this research. If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Dr Brian Finch, Director - Ethics, telephone 06 3569099 ext 86015, email [humanethics@massey.ac.nz](mailto:humanethics@massey.ac.nz).

If you are interested in participating in the survey, please find the link below:

[Cognitive and Neuropsychological assessment with children](#)

If the link above does not work, please try the link below:

[https://qau1.au1.qualtrics.com/SE/?SID=SV\\_3NKKU0mo0Me1Z2t](https://qau1.au1.qualtrics.com/SE/?SID=SV_3NKKU0mo0Me1Z2t)

Please feel free to pass this on to other psychologists who complete cognitive and neuropsychological assessments with children, who may be interested in participating.

Thank you very much for your time.

Nga mihi,

Kate Ross-McAlpine

## Appendix F: Online Survey



### A survey of psychologists administering cognitive and neuropsychological assessments with New Zealand children

#### Information Sheet

**Why are you being asked to participate?**

This research is investigating aspects of cognitive /neuropsychological assessment of children in New Zealand by psychologists in the education or clinical sectors. You have been invited to participate because of your expertise in this area.

**What are the aims of this research?**

This survey will investigate the use of specific psychometric measures in cognitive /neuropsychological assessments and clarify the test selection process. The survey will also gather the professional opinions on cultural and ethical issues of cognitive/ neuropsychological assessments in New Zealand.

**Who is doing this research?**

My name is Kate Ross-McAlpine and I am a student at Massey University. I am conducting this research as a partial requirement of completing a Doctoral degree in Clinical Psychology. The primary supervisor for this research is Professor Janet Leathem of Massey University's Wellington campus.

**What happens to the information you provide?**

The findings from this survey will form part of a DClinPsych thesis and be submitted for publication in a scientific journal.

Please note that you will never be personally identified in this research project or in any publication. This information you provide will be analysed as group data.

**What happens to the information you provide?**

The findings from this survey will form part of a DClinPsych thesis and be submitted for publication in a scientific journal.

Please note that you will never be personally identified in this research project or in any publication. This information you provide will be analysed as group data.

**Your rights as a participant**

You are under no obligation to accept this invitation to participate in the survey. Completion of this questionnaire implies consent. You have the right to not answer any particular question.

If you would like to know the results of this study, they can be emailed to you upon request.

If you have any questions regarding this study you can contact either the researcher or the supervisor via the details given below.

Nga mihi,  
Kate Ross-McAlpine

## Instructions and consent

This questionnaire consists of a series of questions in three parts which will ask about your professional experience as a psychologist in the Education or Clinical sectors, your use of specific psychometric measures and your professional opinions on cultural and ethical issues.

**Part 1: Your Professional Experience**

**Part 2: Test Selection**

**Part 3: Cultural and ethical appropriateness of measures in NZ**

The questionnaire should take 20 minutes to complete.

Please complete all the questions if possible.

**Thank you for participating in this study.**

Kate Ross-McAlpine

## Consent

Your participation implies consent.

You have the right to decline to answer any particular question.

I have read and understood the information sheet for this study and consent to collection of my responses.

*(Please click on the 'Yes' choice if you wish to proceed.)*

Yes

No

## Part 1: Your Professional Practice

What is your scope of practice/ registration?

- Educational Psychologist
- Clinical Psychologist
- Psychologist (general)
- Intern Psychologist (educational)
- Intern Psychologist (clinical)
- Intern Psychologist (general)

Current work (*select all that apply*)

- DHB
- Community / NGO's
- Education sector
- Private
- University
- ACC Contractor
- Other

Over the last 12 months, how frequently would you have administered a cognitive/neuropsychological assessment with a child?

- Weekly
- 2-3 weekly
- Monthly
- 2- 6 monthly
- Between 6 and 12 months
- Once

For which (if any) assessment measures do you use computerised **administration**?

For which (if any) assessment measures do you use computerised **scoring**?

How many years of clinical experience in cognitive/neuropsychological assessment of children do you have?

- Less than 1 year
- 1-4 years
- 5-9 years
- 10-14 years
- 15-20 years
- 20 years +

Place of your clinical training

Country

University (*optional*)

## Part 2: Test selection

This section will ask about your use of specific measures that could be used in a cognitive/neuropsychological assessment with a child.

You will be asked to indicate what measures you use and why you may or may not use them. You will be asked about measures in two parts.

Part A will list 6 comprehensive measures.

- A1. Wechsler Intelligence Scale for Children (WISC-IV or WISC-V)
- A2. A Developmental NEuroPSYchological Assessment (NEPSY-II)
- A3. Delis Kaplan Executive Functioning Scale (DKEFS)
- A4. Wechsler Preschool and Primary Scale of Intelligence-IV (WPPSI-IV)
- A5. Children's Memory Scale (CMS)
- A6. Stanford-Binet-V (SB5)

Part B will ask your use of measures of domain-specific and subjective measures (rating scales).

The list of measures in Part B is designed to be thorough but not exhaustive. Therefore there is the opportunity to add measures that you use currently in your practice that are not included in Part B.

### Test Selection Part A 21

#### Wechsler Intelligence Scale for Children-IV

If you have recently started using the WISC-V please respond based on your practice using the WISC-IV.

Do you currently use the WISC in your practice?

- Yes
- No

---

<sup>21</sup> For the reader of this thesis this footnote provides a detailed explanation of how Part Two: Test Selection, Part A was structured. The answer to the question on use of a measure determined what page the participant was taken too; if yes, they were taken to a page that asked about subtest use (page 124 for the WISC-IV) and if no, they were taken to a page that asked about reasons they do not use that measure (page 125 for the WISC-IV). This was automatic for the online survey. Each option is in this appendix for completeness.

Wechsler Intelligence Scale for Children-IV

Please indicate the frequency of which you use the WISC-IV subtests in your practice.

	Frequency of use				
	Always	Almost always	Sometimes	Almost never	Never
10 main subtests	●	●	●	●	●
Full 15 subtests	●	●	●	●	●
Block Design	●	●	●	●	●
Similarities	●	●	●	●	●
Digit Span	●	●	●	●	●
Matrix Reasoning	●	●	●	●	●
	Always	Almost always	Sometimes	Almost never	Never
Vocabulary	●	●	●	●	●
Arithmetic	●	●	●	●	●
Symbol Search	●	●	●	●	●
Visual Puzzles	●	●	●	●	●
Information	●	●	●	●	●
Coding	●	●	●	●	●
	Always	Almost always	Sometimes	Almost never	Never
Letter-No. Sequencing	●	●	●	●	●
Figure Weights	●	●	●	●	●
Comprehension	●	●	●	●	●
Cancellation	●	●	●	●	●
Picture Completion	●	●	●	●	●

**Wechsler Intelligence Scale for Children-IV**

Each measure and subtests has strengths, weakness / positive and negative attributes which may affect your decision to use them or not. These may include, but are not limited too; familiarity, access, cost, time, psychometric properties, cultural appropriateness or reputation.

Please provide any comments or opinions about your use of this measure or these subtests:

**Wechsler Intelligence Scale for Children-IV**

Why do you not currently use the WISC-IV?

- Lack of familiarity with test
- Lack of access to test materials
- Cost of test
- Length of administration time
- Limited/no training on this test
- Psychometric properties
- Reputation
- Culturally inappropriate
- Purpose of the assessment
- Other

-----

A Developmental NEuroPSYchological Assessment (NEPSY-II)

Do you currently use the NEPSY-II in your practice?

Yes

No

A Developmental NEuroPSYchological Assessment (NEPSY-II )

Please indicate the frequency of which you use the NEPSY-II subtests in your practice.

	Frequency of use				
	Always	Almost always	Sometimes	Almost never	Never
All	<input checked="" type="radio"/>				
Affect recognition	<input checked="" type="radio"/>				
Animal Sorting	<input checked="" type="radio"/>				
Arrows	<input checked="" type="radio"/>				
Auditory Attention and Response Set	<input checked="" type="radio"/>				
Block Construction	<input checked="" type="radio"/>				
Clocks	<input checked="" type="radio"/>				
Comprehension of Instructions	<input checked="" type="radio"/>				
	Always	Almost always	Sometimes	Almost never	Never
Design Copying	<input checked="" type="radio"/>				
Fingerip Tapping	<input checked="" type="radio"/>				
Geometric Puzzles	<input checked="" type="radio"/>				
Imitating Hand Positions	<input checked="" type="radio"/>				
Inhibition	<input checked="" type="radio"/>				
List Memory	<input checked="" type="radio"/>				
Manual Motor Sequences	<input checked="" type="radio"/>				
Memory for Designs	<input checked="" type="radio"/>				
	Always	Almost always	Sometimes	Almost never	Never
Memory for Faces	<input checked="" type="radio"/>				
Memory for Names	<input checked="" type="radio"/>				
Narrative Memory	<input checked="" type="radio"/>				
Oromotor Sequences	<input checked="" type="radio"/>				
Phonological Processing	<input checked="" type="radio"/>				
Picture Puzzles	<input checked="" type="radio"/>				
Repetition of Nonsense Words	<input checked="" type="radio"/>				
Route Finding	<input checked="" type="radio"/>				

	Always	Almost always	Sometimes	Almost never	Never
Sentence Repetition	●	●	●	●	●
Speeded Naming	●	●	●	●	●
Statue	●	●	●	●	●
Theory of Mind	●	●	●	●	●
Word Generation	●	●	●	●	●

### A Developmental NEuroPSYchological Assessment (NEPSY-II )

Each measure and subtests has strengths, weakness / positive and negative attributes which may affect your decision to use them or not. These may include, but are not limited too; familiarity, access, cost, time, psychometric properties, cultural appropriateness or reputation.

Please provide any comments or opinions about your use of this measure or these subtests:

-----

A Developmental NEuroPSYchological Assessment (NEPSY-II )  
Why do you not use the NEPSY-II?

- Lack of familiarity with test
- Lack of access to test materials
- Cost of test
- Length of administration time
- Limited/no training on this test
- Psychometric properties
- Reputation
- Culturally inappropriate
- Purpose of the assessment
- Other

Delis-Kaplan Executive Function Scale (DKEFS)

Do you currently use the DKEFS in your practice **with children**?

- Yes
- No

-----

Delis-Kaplan Executive Function Scale (DKEFS)

Please indicate the frequency of which you use the DKEFS subtests in your practice **with children**.

	Always	Almost always	Sometimes	Almost never	Never
All	●	●	●	●	●
Trail Making Test	●	●	●	●	●
Verbal Fluency	●	●	●	●	●
Design Fluency	●	●	●	●	●
Colour-Word Interference	●	●	●	●	●
Sorting	●	●	●	●	●
Twenty Questions	●	●	●	●	●
Word Context	●	●	●	●	●
Tower	●	●	●	●	●
Proverb	●	●	●	●	●

Delis-Kaplan Executive Function Scale (DKEFS)

Each measure and subtests has strengths, weakness / positive and negative attributes which may affect your decision to use them or not. These may include, but are not limited too; familiarity, access, cost, time, psychometric properties, cultural appropriateness or reputation.

Please provide any comments or opinions about your use of this measure or these subtests **with children**:

-----

Delis-Kaplan Executive Function Scale (DKEFS)  
Why do you not currently use the DKEFS with children?

- Lack of familiarity with test
- Lack of access to test materials
- Cost of test
- Length of administration time
- Limited/no training on this test
- Psychometric properties
- Reputation
- Culturally inappropriate
- Purpose of the assessment
- Other

-----

Wechsler Preschool and Primary Scale of Intelligence-IV (WPPSI-IV)

Do you currently use the WPPSI-IV in your practice?

- Yes
- No

-----

Wechsler Preschool and Primary Scale of Intelligence-IV (WPPSI-IV)

Please indicate the frequency of which you use the WPPSI-IV subtests in your practice.

	Always	Almost always	Sometimes	Almost never	Never
All	●	●	●	●	●
Receptive Vocabulary	●	●	●	●	●
Picture Memory	●	●	●	●	●
Zoo Location	●	●	●	●	●
Bug Search	●	●	●	●	●
Animal Coding	●	●	●	●	●
Cancellation	●	●	●	●	●
Vocabulary	●	●	●	●	●
	Always	Almost always	Sometimes	Almost never	Never
Information	●	●	●	●	●
Picture naming	●	●	●	●	●
Object Assembly	●	●	●	●	●
Block Design	●	●	●	●	●
Word Reasoning	●	●	●	●	●
Similarities	●	●	●	●	●
Comprehension	●	●	●	●	●
	Always	Almost always	Sometimes	Almost never	Never
Matrix Reasoning	●	●	●	●	●
Picture Concepts	●	●	●	●	●
Picture Completion	●	●	●	●	●
Coding	●	●	●	●	●
Symbol Search	●	●	●	●	●

Wechsler Preschool and Primary Scale of Intelligence-IV (WPPSI-IV)  
Each measure and subtests has strengths, weakness / positive and negative attributes which may affect your decision to use them or not. These may include, but are not limited too; familiarity, access, cost, time, psychometric properties, cultural appropriateness or reputation.

Please provide any comments or opinions about your use of this measure or these subtests:

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Wechsler Preschool and Primary Scale of Intelligence-IV (WPPSI-IV)  
Why do you not use currently use the WPPSI-IV?

- Lack of familiarity with test
- Lack of access to test materials
- Cost of test
- Length of administration time
- Limited/no training on this test
- Psychometric properties
- Reputation
- Culturally inappropriate
- Purpose of the assessment
- Other

-----

Children's Memory Scale (CMS)

Do you currently use the CMS in your practice?

- Yes
- No

Children's Memory Scale (CMS)

Please indicate the frequency of which you use the CMS subtests in your practice.

	Frequency of use				
	Always	Almost always	Sometimes	Almost never	Never
All	●	●	●	●	●
Core subtests	●	●	●	●	●
Stories Recall	●	●	●	●	●
Word Pairs	●	●	●	●	●
Dot Locations	●	●	●	●	●
Faces	●	●	●	●	●
Numbers	●	●	●	●	●
Sequences	●	●	●	●	●
Word Lists	●	●	●	●	●
Family Pictures	●	●	●	●	●
Picture Locations	●	●	●	●	●

Children's Memory Scale (CMS)

Each measure and subtests has strengths, weakness / positive and negative attributes which may affect your decision to use them or not. These may include, but are not limited too; familiarity, access, cost, time, psychometric properties, cultural appropriateness or reputation.

Please provide any comments or opinions about your use of this measure or these subtests:

-----

Children's Memory Scale (CMS)  
Why do you not currently use the CMS?

- Lack of familiarity with test
- Lack of access to test materials
- Cost of test
- Length of administration time
- Limited/no training on this test
- Psychometric properties
- Reputation
- Culturally inappropriate
- Purpose of the assessment
- Other



Stanford-Binet-V (SB5)

Do you currently use the SB5 in your practice?

- Yes
- No

Stanford-Binet-V (SB5)

Please indicate the frequency of which you use the SB5 subtests in your practice.

	Frequency of use				
	Always	Almost always	Sometimes	Almost never	Never
All	●	●	●	●	●
Early Reasoning	●	●	●	●	●
Verbal Absurdities	●	●	●	●	●
Verbal analogies	●	●	●	●	●
Object series matrices	●	●	●	●	●
Vocabulary	●	●	●	●	●
	Always	Almost always	Sometimes	Almost never	Never
Procedural knowledge	●	●	●	●	●
Picture absurdities	●	●	●	●	●
Non-verbal quantitative reasoning	●	●	●	●	●
Verbal quantitative reasoning	●	●	●	●	●
Form board and form patterns	●	●	●	●	●
Position and direction	●	●	●	●	●
	Always	Almost always	Sometimes	Almost never	Never
Delayed response	●	●	●	●	●
Block span	●	●	●	●	●
Memory for sentences	●	●	●	●	●
Last word	●	●	●	●	●

Stanford-Binet-V (SB5)

Each measure and subtests has strengths, weakness / positive and negative attributes which may affect your decision to use them or not. These may include, but are not limited too; familiarity, access, cost, time, psychometric properties, cultural appropriateness or reputation.

Please provide any comments or opinions about your use of this measure or these subtests:

Stanford-Binet-V (SB5)  
Why do you not currently use the SB5?

- Lack of familiarity with test
- Lack of access to test materials
- Cost of test
- Length of administration time
- Limited/no training on this test
- Psychometric properties
- Reputation
- Culturally inappropriate
- Purpose of the assessment
- Other

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Test selection Part B

Domain specific measures and rating scales

Please indicate the frequency of which you use any domain-specific measures or rating scales you use in your practice.

Each measure and subtests has strengths, weakness / positive and negative attributes which may affect your decision to use them or not. These may include, but are not limited too; familiarity, access, cost, time, psychometric properties, cultural appropriateness or reputation.

Therefore please also indicate for each subtest, where appropriate, any reasons that explain the frequency/infrequency of your use.

	Frequency of use					Reasons for frequency or infrequency of use
	Always	Almost always	Sometimes	Almost never	never	
Adaptive Behavioural Assessment System- II - Parent	●	●	●	●	●	<input type="text"/>
Adaptive Behavioural Assessment System- II - Teacher	●	●	●	●	●	<input type="text"/>
Automated Working Memory Assessment (AWMA)	●	●	●	●	●	<input type="text"/>
Bayley Scales of Infant and Toddler Development	●	●	●	●	●	<input type="text"/>
Behaviour Assessment System for Children (BASC) - Parent	●	●	●	●	●	<input type="text"/>
Behaviour Assessment System for Children (BASC) - Teacher	●	●	●	●	●	<input type="text"/>

	Always	Almost always	Sometimes	Almost never	never	
Behaviour Assessment System for Children (BASC) – Structured Developmental History	●	●	●	●	●	<input type="text"/>
Behaviour Assessment Scale for Children (BASC) - Self	●	●	●	●	●	<input type="text"/>
Behaviour Rating Inventory for Executive Functioning (BRIEF) - Parent	●	●	●	●	●	<input type="text"/>
Behaviour Rating Inventory for Executive Functioning (BRIEF) - Teacher	●	●	●	●	●	<input type="text"/>
Bender Gestalt Test	●	●	●	●	●	<input type="text"/>
California Verbal Learning Test – Children’s Version (CVLT-C)	●	●	●	●	●	<input type="text"/>
Child Behaviour Checklist (CBCL)	●	●	●	●	●	<input type="text"/>
Children’s Auditory Verbal Learning Test-2 (C-AVLT-2)	●	●	●	●	●	<input type="text"/>

Always    Almost always    Sometimes    Almost never    never

Clinical Evaluation of Language Fundamentals 4th (CELF-4)	●	●	●	●	●	<input type="text"/>
Conners Continuous Performance Scale -3 (Conners CPS-3)	●	●	●	●	●	<input type="text"/>
Conners Comprehensive Behaviour Rating Scales - Parent	●	●	●	●	●	<input type="text"/>
Conners Comprehensive Behaviour Rating Scales - Teacher	●	●	●	●	●	<input type="text"/>
Conners Comprehensive Behaviour Rating Scales - Self	●	●	●	●	●	<input type="text"/>
Peabody Picture Vocabulary Test – 4th (PPVT-4)	●	●	●	●	●	<input type="text"/>
Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)	●	●	●	●	●	<input type="text"/>
Stroop Colour and Word Test: Children's Version	●	●	●	●	●	<input type="text"/>
Test of Everyday Attention – Children (TEA-Ch)	●	●	●	●	●	<input type="text"/>
Vineland Adaptive Behaviour Scale – 2th - Parent	●	●	●	●	●	<input type="text"/>

Always    Almost always    Sometimes    Almost never    never

Vineland Adaptive Behaviour Scale – 2th - Teacher

Vineland Adaptive Behaviour Scale – 2th - Survey Interview Form

Wechsler Individual Achievement Test-3rd Edition (WIAT-3)

Wide Range Achievement Test-4 (WRAT-4)

Do you use another measure that is not on the list above?

Yes (Please specify)

No

Do you use another measure that is not on the list above?

Yes (Please specify)

No

Do you use a measure to assess effort with children?

Yes (Please specify which measure/s you use)

No

-----

### Part Three: Cultural and Ethical Considerations of assessments in NZ

Based on the New Zealand Code of Ethics there is an ethical obligation to ensure measures used have “established scientific status” as well as consideration to the “cultural appropriateness” of assessment procedures and measures (2.1.3; page 13 [NZ Code of Ethics](#))

The following two questions are based on the cognitive /neuropsychological measures you selected in part 2.

In your professional opinion, how culturally appropriate are the measures you use for children in New Zealand?

Do you change anything in the administration for use for New Zealand children?  
*For example names of people, or Mom --> Mum*

- Yes
- No

If yes, what do you change?  
*For example names of people, or Mom --> Mum*

In your professional opinion do you think it is necessary to collect normative data for measures used with NZ children?

- Yes
- No
- Not sure

Please comment.

Any final comments



Thank you for your contribution to research with New Zealand Psychologists.

This section of the survey is separate from your earlier answers and provides you with the opportunity to receive a summary of results. If you wish to receive a summary of findings, please click the **next** button of this page.

If you have any questions or queries regarding this project, please don't hesitate to contact the following:

Researcher  
Kate Ross-McAlpine  
School of Psychology  
Wellington Campus  
Massey University  
Wellington  
Email: [kateross.mcalpine@gmail.com](mailto:kateross.mcalpine@gmail.com)

Supervisor  
Professor Janet Leathem  
School of Psychology  
Wellington Campus  
Massey University  
Wellington  
+64 4 801-5799 ext 63610  
[J.M.Leathem@massey.ac.nz](mailto:J.M.Leathem@massey.ac.nz)

Massey University School of Psychology – Te Kura Hinengaro Tangata  
Wellington, New Zealand  
T +64 4 801-5799 ext 85071 : W [psychology.massey.ac.nz](http://psychology.massey.ac.nz)

This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Dr Brian Finch, Director - Ethics, telephone 06 3569099 ext 86015, email [humanethics@massey.ac.nz](mailto:humanethics@massey.ac.nz).

## Appendix G: Research Summary for Participants



### A Summary for participants

#### A survey of psychologists administering cognitive and neuropsychological assessments with New Zealand children

The purpose of the study was to gather information about the cognitive testing processes with New Zealand children through a survey of New Zealand psychologists. There were two aims 1. to determine the patterns of test use, specifically the frequency of test and subtest use, as well as the reasons for test selection and 2. to provide perspectives on the impact and influences of cultural in cognitive and neuropsychological assessments with children.

The main results are summarised below:

- The WISC-IV was the most commonly used comprehensive measure to assess cognitive and neuropsychological function of New Zealand children
- The most commonly used rating scales were the ABAS, CBCL and CCBRS.
- Test selection was primarily explained by pragmatic considerations such as familiarity and access.
- Most respondents (72.6%) did not administer a measure to assess effort.
- Most respondents did not use computerised administration in their assessments (71.7%) however most respondents used computerised scoring (65%).
- Most respondents felt there was a need for normative data for New Zealand, (80.3% said 'yes', 9.1% were 'not sure' and 4.5% of respondents said 'no').
- Most respondents (69.7%) stated that they changed aspects of administration for use with NZ children some examples were, fall to autumn and trash to rubbish.
- The most common themes when asked about cultural appropriateness of measures, was a concern for specific persons and peoples (24%), a sense that the measures were adequate (16%) and that clinical judgement was required (11%).

This paper has been accepted for publication in the New Zealand Journal of Psychology.

Thank you again for your time and contribution to this research.

Kate Ross-McAlpine

## **Appendix H: A Research Case Study<sup>22</sup>**

A Research Case Study: How my doctoral thesis research has contributed to my clinical practice as a clinical psychology intern

Kate Ross-McAlpine

Doctor of Clinical Psychology Candidate, Massey University Wellington

Clinical Psychology Intern at Adult Community Mental Health, Bay of Plenty District Health Board

This case study represents the work of Kate Ross-McAlpine during her thesis from 2015 to 2017 and reflections as an intern psychologist in 2017.

### **Abstract**

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<sup>22</sup> This case study was completed as a requirement of the Doctor of Clinical Psychology training program. The purpose of this case study is for doctoral candidates to consider the impact their research process has had on their clinical work during their internship. This case study was included in the author's 2017 examinations.

This research case study reviews my doctoral thesis and provides reflections on transitioning from researcher to clinical psychology intern. The case study is composed of two sections. The first section will provide an overview of my thesis; aspects of typical neuropsychological development and assessment with children in New Zealand. The thesis topic development will be outlined and the three research studies aims, methodology and initial results will be summarised. The second section is a discussion on my self-reflections transitioning from a researcher into my role as an intern psychologist with an Adult Community Mental Health Team at Bay of Plenty District Health Board. These reflections include discussions on working with adults compared to children, working in a team, self-confidence, observing test-taking behaviour and the clinical value of cognitive assessments in clinical practice.

*Keywords: Research, self-reflection, intern, clinical psychology*

My doctoral thesis topic focused on aspects of typical neuropsychological development and assessment with children in New Zealand. This overview of my thesis will firstly include a summary of the development of the thesis topic followed by an overview of the aims, methodology and initial results of the three research studies.

### **Thesis Topic Development**

In 2012 the School of Psychology at Massey University in Wellington was invited to collaborate with The Centre for Public Health Research (CPHR) on a research project. This project aimed to investigate the relationship between pesticide exposure and neurodevelopmental effects in New Zealand children. The School of Psychology was asked to provide guidance and support regarding the assessment of neuropsychological functioning and behavioural symptoms.

The opportunity for me to be involved was first discussed in May 2014 for an Honours research project to my strong interest in child neuropsychology. Due to time delays of the larger project, my involvement was postponed until 2015 aligning with my commencement in the Doctor of Clinical Psychology programme. In early 2015 an extensive review of the literature was conducted in order to determine if independent research could be developed from the data being collected. This review explored the literature on neuropsychological development in childhood and neuropsychological assessment of children. Based on this review it was evident that research in this area is not only warranted but urgently needed. It was at this point that I joined the project.

This initial literature review that backgrounded the research in this area will be summarised below, followed by an overview of the CPHR research project will be provided for greater context.

Initial findings in the literature identified that research on neuropsychological development in middle childhood (6 to 12 years old) is neglected (Korkman, 2001). This age range is described as having less pronounced developmental change than other developmental groups such as infancy and adolescence (Bauer et al., 2011) and therefore has been neglected by developmental neuropsychological research. The majority of research that does investigate neuropsychological development, focused on the development of one or two cognitive domains only (Bock et al., 2015; Luz et al., 2014). Due to the overlapping nature of cognitive abilities, consideration of a number of cognitive domains is critical in understanding neuropsychological development from a comprehensive perspective. Therefore, a thorough investigation of the inter-relationships between multiple cognitive domains during development in middle childhood is necessary.

There is no empirical research identifying commonly used measures during neuropsychological or cognitive assessments with children in New Zealand. Research was conducted exploring general psychometric use in New Zealand (Dunn & Dugdale, 2002) but there has been no focus on test use with neuropsychological or cognitive assessments with children. The appropriateness of measures developed outside of New Zealand to assess New Zealand children remains unclear. Research had found cultural biases with Māori children on a measure of vocabulary (Haitana et al., 2010). Furthermore, it was currently unclear if psychologists who regularly administer these cognitive and neuropsychological assessments were aware of cultural influences on performance or if they make adaptations for use with New Zealand children. The practice of cognitive and neuropsychological assessments with children in New Zealand has received little research attention.

In summary, the current thesis idea was sparked by an opportunity for collaboration with the CPHR. This collaboration provided a catalyst for inspiration and the opportunity to collect and utilise data from a larger research project. Significant gaps in the literature were identified which lead to the thesis topic develop on the neuropsychological development and assessment of children.

### **Research Study Aims**

The rationale for this thesis is driven by a lack of literature on both the neuropsychological development in middle childhood and the practice of cognitive and neuropsychological assessments with children in New Zealand. Thereby the two overlapping themes of this thesis are typical neuropsychological development in middle childhood and the practice of neuropsychological assessment with children. These two themes developed into three research studies. The aims and methodology of the three studies will be outlined below. Study 1 and 2 were completed in collaboration with the CPHR research project and Study 3 was conducted independently.

**Study 1: Age effects in neuropsychological measures for typically developing children aged 6 to 11 years.** The aim of Study 1 is to investigate age effects in neuropsychological development and compare the functioning of a sample of New Zealand children with overseas normative groups.

**Study 2: Relationships between cognitive domains and school achievement in typically developing New Zealand children.** The aim of study 2 is investigate relationships between cognitive domains and school achievement during middle childhood.

**Study 3: A survey of psychologists administering cognitive and neuropsychological assessment with New Zealand children.** The aim of Study 3 is to explore aspects of neuropsychological and cognitive assessments in the context of New Zealand.

**Methodology: Study I and 2<sup>23</sup>**

**Ethics**

Ethical approval was sort by the larger CPHR research project and was granted by the Human Disability Ethics Committee (reference no. NZ171E3013). Consent forms were obtained from all participants and participants had the right to withdraw from the study at any point. Assent was obtained from each child prior to the administration of the neuropsychological assessment. All research data was kept anonymous and in a secure location.

**Participants**

**Recruitment.** Schools in four regions around New Zealand were approached regarding the CPHR study and initial meetings with school principals were arranged where the research topic, aims and processes were discussed. Once a school confirm their interest in the research, invitation letters were sent to the parents. A total of 30 schools were involved in the research.

**Exclusion Criteria.** Children were individually excluded from the study if they had a mental health disorder that would impact their performance, including; intellectual disability, global developmental delay or ADHD.

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<sup>23</sup> As mentioned, Study 1 and 2 were conducted in collaboration with CPHR and therefore share the same methodology

## **Neuropsychological assessment**

The aim of the neuropsychological assessment was to assess across the cognitive domains, using age appropriate, recent and psychometrically reliable. The length of testing and age of children and testing within a school day lead to the decision the assessment should be approximately one hour. The requirements of the larger study for the neuropsychological assessments necessitated that the assessments cover the cognitive domains and multiple aspects of attention.

Based on the different number of cognitive assessment measures used for assessing children and consideration of the test selection process, a number of possible neuropsychological measures were discussed and reviewed during a panel test selection process. The test selection process involved a thorough discussion with the supervisor, the author and research colleagues and took place over two days. The selection panel included both males and females of various ages and a cultural advisor was consulted. The tests selected were from the Neuropsychological Development measure (NEPSY-II), Wechsler Intelligence Scale for Children (WISC-IV) and the Test of Everyday Attention for children (TEA-Ch).

The neuropsychological assessments were completed during the school terms between May 2015 and December 2016.

## **Procedure**

Initial recruitment meetings with school principals were arranged to discuss the research project. Once each school confirmed their interest in participation, research information and consent forms are sent to parents through the school. When the consent forms are returned,

parents were sent a questionnaire for the CPHR project. Once this questionnaire was completed and returned, the parents then received a letter inviting their child to participate in the neuropsychological assessment phase.

Children were excused from their classroom for approximately one hour during a typical school day to participate in the neuropsychological assessment. The assessments were completed on a one-to-one basis with the researcher.

### **National Standards**

National standards are a Ministry of Education initiative to outline clear expectations for the knowledge and skills that children in New Zealand need to achieve at each level, from year 1 to year 8. The standards are across three achievement areas; reading, writing and mathematics. For each of these three areas a child's achievement is categorised by their teacher as being; above, at or below the standard. The national standards of achievement were obtained through the schools. Due to the nature and scope of this project, using the child's national standards was the most appropriate method to obtain information regarding each participant's achievement.

## **Methodology: Study 3**

### **Ethics**

A low-risk ethics notification was obtained for the survey (reference no. 4000015338).

### **Survey Design**

The survey underwent a number of revisions, in order to effectively ask questions and gather opinions whilst ensuring the questions were not suggestive or offensive. The survey was designed to take approximately 20 minutes to complete.

The survey comprised of three sections; clinical practice, test selection and cultural considerations. The first section on clinical practice included 7 demographic questions. The second section, on test selection, included questions on the frequency of use of 6 comprehensive measures (WISC-IV, NEPSY-II, CMS, WPPSI-IV, DKEFS, SB5) and the frequency of subtest use rated on a 5-point likert scale. Respondents were able to comment on the reasons that explained their frequency of use. The respondents who indicated they currently *do not* use one of the 6 comprehensive measures, were asked to identify the reasons for this. The use of specific assessment measures and rating scales that could be used in a cognitive or neuropsychological assessment with a child was also surveyed. The use of measures of effort and use of computerised administration and scoring was also included. The third part of the survey, included open ended questions on opinions on cultural appropriateness, the need for NZ normative data, as well as respondents make adaptations to administration.

## **Procedure**

Invitation to participate in this survey was distributed using three recruitment methods. Firstly, information about the survey, including a link to the survey was provided in the June 2016 New Zealand Society of Psychologists (NZSPs) Connections magazine. Secondly, an email was sent through to the members of three professional groups; the New Zealand College of Clinical Psychologists (NZCCP), the New Zealand Special Interest Group in Neuropsychology

(NZ SIGN) and the Massey Psychology Clinics. Thirdly, participants were also recruited through word of mouth within the psychological community. The survey was online during June and August of 2016.

## **Summary of Initial Results**

**Study 1: Age effects in neuropsychological measures for typically developing children aged 6 to 11 years.** Firstly, age effects were found for all measures of cognitive abilities which is consistent with previous research (Korkman et al., 2013; Rosenqvist et al., 2017; Rosselli et al., 2010). Post-hoc findings identified the most significant improvement occurred between ages 6 and 9 years. Secondly, scaled scores of the NZ sample were within  $\pm 0.4$  of a standard deviation standard score of the overseas normative groups for all tests except for finger tapping (NEPSY-II), where NZ children performed one standard deviation higher than the US standardisation group. The findings from this study indicate that majority of the measures can be used with some confidence with New Zealand children until normative groups are established.

**Study 2: Relationships between cognitive domains and school achievement in typically developing New Zealand children.** The results from this study are still being analysed. However, initial correlational results identified moderate-weak correlations between cognitive domains, and between cognitive domains and school achievement.

**Study 3: A survey of psychologists administering cognitive and neuropsychological assessment with New Zealand children.** Consistent with previous research (Dunn & Dugdale, 2002) the WISC-IV was the most commonly used comprehensive measure to assess cognitive

and neuropsychological function of New Zealand children. The most commonly used domain specific/rating scales, the ABAS, CBCL and CCBRS, reflect the emphasis on adaptive and difficult behaviour in the context of cognitive and neuropsychological assessments. The results of the survey indicated that test selection appears dominated by pragmatic considerations such as lack of familiarity and access. The majority of respondents did not use a measure of effort with children, perhaps due to only 16.7% of respondents working for ACC where assessment of effort is expected. Concerns raised regarding cultural sensitivity in the current study align with recent discussions on the need to recognise the diversity within New Zealand (Dudley et al., 2016). Respondents' concerns demonstrate an awareness and sensitivity to culture within their psychological practice e.g., changing '*family*' to '*whānau*' during assessment administration. The focus on the diversity of New Zealand was also reflected in the finding that the majority of the survey respondents considered it important to obtain normative data for New Zealand children (80.3%). The post hoc findings showed that clinical psychologists were more likely to utilise a range of psychometrics than other scopes of practice. The current study also found that the CMS is used more by experienced respondents, perhaps because published in 1997 it may have been more familiar to them, with some preferring the CMS subtests over the NEPSY memory subtests. Regardless, there are potential Flynn effect cautions in using a dated test in neuropsychological assessments (Dickinson & Hiscock, 2011).

In summary, the findings from Study 3 highlighted test and subtest preferences and provided insights into why particular measures are being selected. The majority of respondents had a sensitivity to and consideration for diversity and culture which was demonstrated through comments made about whether measures are culturally appropriate, concerns for specific peoples and persons, adaptations made for use in NZ and the need for normative data.

## **Clinical Psychology Internship**

In January 2017, I started at the Bay of Plenty District Health Board in Tauranga as a clinical psychology intern. This year-long internship is split across two mental health settings; six months at Adult Community Mental Health and Child and six months at Adolescent Mental Health Services. This research case study is written during my first 6 months of my internship while I was placed at Adult Community Mental Health. The following section provides a discussion and self-reflection on my transition from a researcher to intern psychologist working at Adult Community Mental Health. My reflections include; working with children compared to adults, working in a team, self-confidence, test-taking behaviour and clinical value of cognitive assessments in clinical practice. These reflections will be discussed below.

### **Working with children compared with adults**

One of the most noticeable difference between my thesis research and internship work is the age range of the individuals; my thesis focused on children and my internship at the time of writing is in Adult Community Mental Health. The differences were clearly evident for me, particularly around engagement, manner of establishing rapport and assessment administration. In particular, I'd become accustomed to and expect the natural trust, ease and excitement that most children had. The children had time out of their class room to complete the assessments, as time out of the classroom is rare, it could have contributed to the excitement they had. When I starting working with adults, there was a significant contrast, as some of the adults I worked with presented as abrasive and distrusting. In my short experience, excitement is almost non-existent in an adult community mental health setting.

## Psychometric measures

As mentioned, the two biggest reasons for not using psychometrics identified in Study 3, were lack of familiarity and access. This was something I didn't understand completely until I started my internship. It became clear that lack of access to psychometric materials is a significant barrier in clinical practice. Furthermore, the opportunity for being familiar with new psychometrics in practice, was only observed in my internship to specific situations when a commonly used measure has been updated. This finding in my thesis was something I found myself reflecting on as an intern.

During my internship at adult community mental health, I reflected on the different psychometric measures that are available for adults or children. I was very familiar with the various neuropsychological assessments measures for children, having used some of them, as well as having spent time researching various others. I had a discussion with my internship supervisor about measures of social perception or what he termed "social intelligence". I spoke to him about the social perception domain on the NEPSY-II and described the Affect Recognition and Theory of Mind tasks. However, in our discussions neither of us were aware of an equivalent, normed, objective measure for adults. After some research, I found the "Reading the mind in the eye" test which came out in 1997 and was revised in 2001 (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). This measure assesses Theory of Mind from identifying different expressions around eyes. Comparatively, the NEPSY-II assesses social perception in more varied ways including, *facial* expression of emotion and theory of mind in verbal and contextual scenarios. I reflected that NEPSY-II equivalent social perception domains would be advantageous for adults.

In the survey in Study 3, two participants stated they utilised the social perception domain on the NEPSY-II in the context of working with a child with Autism Spectrum Disorder (ASD); *“I have used the affect recognition and theory of mind subtest as a way to assess children with autistic spectrum traits”* and *“I have used theory of mine, memory for names and faces for students with a diagnosis of autism”*. These quotes demonstrate the clinical utility and value of a measure of social perception in the context of ASD assessments with children. Reflecting on this research finding, the conversation I had with my supervisor and the initial research about the Reading the Mind in the Eye Test, it was clear that more objective measures of social perception in clinical practice for adults would be beneficial.

### **Working in a team**

As previously mentioned, aspects of my research involved working collaboratively with CPHR and working within a team. This was a valuable experience as I learnt about the dynamics of working within a team environment and shared comradery during difficult situations. Additionally, I saw the unique individual contributions of team members which enhanced the project and my work within the team. Individual contributions from my team members at CPHR included previous experience with project management, working at schools and being a parent. These experiences all contributed to our team dynamic and success as a team. The challenges of working in a team environment, such as differences in opinions and individual agendas were also helpful for me to experience during this time.

Negotiating team dynamics for two years prior to my internship assisted my transition into the multi-disciplinary team (MDT). Aspects of working within the MDT environment in my internship are similar to my experiences in our CPHR team. This includes the unique

contributions of individual team members from different disciplines. The MDT I am part of as an intern includes nurses, occupational therapists, social workers, psychiatrists, psychologists and our team leaders. I have enjoyed and found value in being challenged by team members' differing opinions, as I did during my team work for my thesis. I personally enjoy being challenged on my viewpoint as it can bring a shift in perspective. The daily MDT team meetings also contribute to my sense of working within and being part of a team. I truly value working in a team environment and my experience during my thesis helped prepare me for working in a MDT during my internship.

### **Self-Confidence**

During the first few months of my internship, my self-confidence for conducting cognitive assessments was higher than all other aspects of my internship work, due to my experience of conducting over 100 cognitive assessments for my thesis. The experience I gained conducting so many assessments with children, significantly contributed to my sense of confidence and familiarity with the process and logistics of conducting cognitive assessments as an intern. I was very grateful to have an area of work early on in my internship year, where I felt some degree of familiarity and confidence in my ability. During this time, I reflected on the significant quantity of assessments I had completed during my thesis. Also, it was a reminder that my confidence in other areas will continue to develop with experience and that I needed to be patient with this process. I am continually learning to be patient with this process.

### **Observing test-taking behaviours**

During a neuropsychological assessment test-taking behaviour and observations provide qualitative information, in addition to quantitative test findings. These observations provide

depth and context to an individuals' performance added to quantitative tests. My research focused primarily on quantitative findings and so the observed behaviours during administering assessments with the children were not always recorded. I reflected on how some qualitative information in my research may have been missed. I also reflected that perhaps test-taking behaviours are of more value when considering an individual's difficulties in clinical practice compared with research purposes, as my research participants were all typically developing children. Perhaps observed behaviours are more informative in a clinical presentation than with typical developing individuals. While reflecting on this, another perspective would be that the value of observed behaviour depends on the behaviours observed and within the context of the referral question, rather than specifically the presence or absence of a clinically significant behaviours.

Comparatively, for a neuropsychological assessment in clinical practice, test-taking behaviours would be observed and recorded as qualitative information. This additional qualitative information is required for a comprehensive clinical assessment.

### **The value of cognitive assessments in clinical practice**

After completing a number of cognitive assessments solely with typically developing children during my research, I had almost forgotten how incredibly helpful cognitive assessments are in a clinical context. During my internship, I found myself realising the significant value of a thorough cognitive assessment not only for the client, but their family/whanau and the professionals working for them. I completed a number of cognitive assessments early on in my internship and came to appreciate the broader value of completing an assessment. Particularly being able to link the concerns in real life directly with cognitive

weaknesses evident in assessment, has been incredibly rewarding for me to see in clinical practice. Additionally, I found personally that providing recommendations for individuals, their families and professionals very rewarding. This was not something I experienced during my research, due to the nature of research assessments, my participant sample and limited ability to provide in-depth feedback. Providing feedback in a clinical setting was a rewarding experience for me, particularly observing the client and family identify with the assessment findings and related this to difficulties the individual is experiencing.

In summary, I believe the various skills I learnt, and experiences I had during my research contributed to my transition into my development as an intern psychologist. Furthermore, I believe these skills and experiences enabled a supported transition for me. I am very grateful for the number of experiences and learning opportunities that I have had during my research which significantly contributed to my professional development.

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## Appendix I: Conference Presentation



### Certificate of Presentation

**KATE ROSS-MCALPINE**

has presented the research titled:

**Age effects in neuropsychological measures for typically developing children age 6 to 11 years**

which was presented at the

**International Neuropsychological Society 2017 Mid-Year Congress,**  
held at the CTICC in Cape Town 05 – 08 July

Ann D. Watts

Annelies Cramer

Programme Chairs: INS 2017 Mid-Year Congress

