Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

Crystallised and Fluid Ability Change Across Age and a Psychometric Evaluation of the GRT2: A Cross-Sectional Analysis

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

Masters of Arts

in

Psychology

At Massey University, Auckland,

New Zealand.

Andrew James McInnes

2011

Abstract

This paper critically evaluated many psychometric properties of the General Reasoning Test (GRT2) and examined age changes in Crystallised and Fluid ability across the 16- to 58-year age range, as represented by the Verbal and Abstract GRT2 scales, respectively. Respondent data came from a large New Zealand-based archived group (*N*=5075) of individuals whom had completed the assessment as a component of general-level pre-employment information gathering. The psychometric evaluation found the GRT2 to possess adequate internal consistency, and a sub-adequate item-difficulty distribution, for both the Abstract and Verbal scales. A cross-sectional analysis of ability suggested a significant linear decline in Fluid intelligence and non-significant change in Crystallised intelligence, across age. Furthermore, heterogeneity of Fluid ability variance appeared to increase significantly across age, whereas Crystallised ability variance did not. Results were interpreted in the context of Horn's theory, especially with the distinction between vulnerable and maintained abilities. Limitations and suggestions for future research are discussed.

Acknowledgements

I would first and foremost like to thank my thesis supervisor, Dr. Richard Fletcher, for his immense contribution, and for his warming words of praise throughout the course of this writing. I would also like to give a very special mention to Dr. Paul Wood of OPRA Group Ltd. for the immeasurable support and intellectual stimulation that he has kindly offered, and oft-forced upon me, over the course of the year. I am also earnestly thankful for the gesture of goodwill from OPRA Group Ltd, in particular Dr. Sarah Burke and Amy-Kate Snowise, for their support and also for allowing me access to the GRT2 New Zealand norm group data. Furthermore, I would like to proffer a big thanks to Psytech UK for access to the GRT2 assessment. Finally, I offer a big thanks to my mother for her unremitting words of encouragement and, in jest, to my flatmates for their oft-unconstructive time-management suggestions. Thank you.

Table of Contents

Abstract **2**

Acknowledgements **3**

Table of Contents **4**

List of Tables **6**

List of Figures **7**

Introduction **8**

Origins of the notion of psychometric intelligence and intelligence testing 8

The structure of intelligence and the notion of 'g' 9

Giving structure to mental ability 9

Cattell's theory of Crystallised and Fluid Intelligence **10**

Investment theory 11

The evidence for Crystallised and Fluid Intelligence 12

Structural evidence 12

Age-related developmental evidence 15

Criticism of Crystallised and Fluid Intelligence 16

Cattell-Horn-Carroll theory of human cognitive ability 17

The Measurement of Crystallised and Fluid Intelligence 19

Measurement of Fluid Intelligence 19

Measurement of Crystallised Intelligence 21

Relationship between Fluid and Crystallised ability 22

Population differences in cognitive ability **24**

Age-related differences in cognitive ability 25

The WAIS body of cognitive decline research 25

A cross-sectional WAIS approach to age-related cognitive decline 26

Summary of cross-sectional investigations into changes in intelligence across age 30

A longitudinal WAIS approach to the question of age-related cognitive decline 30

A short note on the Flynn Effect 34

The present investigation 35

Method **37**

Measure 37

Sub-test characteristics: Verbal and Abstract 37

GRT2 administration 38
Data 38
Age group stratification 40
Data Analyses 41
Internal consistency: reliability analysis 41
Descriptive analysis 41
One-factor versus two-factor model 42
Assessing age-related ability differences and variance 42
Results 44
Internal consistency 44
Descriptive analysis 45
Abstract sub-scale 45
Verbal sub-scale 47
Scale-total descriptives 49
Item difficulty analysis 50
Confirmatory Factor Analysis: One-factor versus two-factor model 51
Group differences 52
MANOVA 52
Post-hoc analysis 55
Roy-Bargmann Stepdown Analysis 57
Age-variance analysis 58
Discussion 60
GRT2 psychometric evaluation 60
The variance in Crystallised and Fluid intelligence explainable by age 61
Limitations 65
Implications and suggestions for future research 66
Reference list 68
Appendices 76
Appendix A: Abstract-Verbal as Fluid and Crystallised intelligence. 76
GRT2 Abstract scales as measures of Cattell's Gf 76
GRT2 Verbal scales as measures of Cattell's Gc 77
Appendix B: Missing data analysis 78
Appendix C: Reliability analysis 81

List of Tables

Table 1. Carroll's (1993) second-order factors 14

Table 2. Respondent frequency per age group 41

Table 3. Reliability analysis: summary table 45

Table 4. Abstract item descriptive statistics 46

Table 5. Verbal item descriptive statistics 48

Table 6. Age group means and standard deviations for the Abstract and Verbal scales 50

Table 7. One-factor versus two-factor model fit statistics 52

Table 8. Box's M statistic for equality of covariance 53

Table 9. MANOVA: representing observed mean difference(s) in composite ability over age 54

Table 10. Levene's test of equality of variances 55

Table 11. Tamhane's post-hoc mean comparison 57

Table 12. Summary of univariate and stepdown ANCOVA analyses on Gf and Gc 58

Table 13. Estimated marginal means of V_{total} independent of A_{total} 58

Table 14. A_{total} and V_{total} variance comparison across Age 59

Table 15. Missing data and item difficulty for Abstract items 78

Table 16. Missing data and item difficulty for Verbal items 79

Table 17. Reliability analysis for Abstract scale: step 1 81

Table 18. Reliability analysis for Verbal scale: step 1 81

List of Figures

Figure 1. Example Hierarchical Model of *g*. 10

Figure 2. Example matrix relations item. Reprinted from "Raven's Matrices mock-up" by S. Bell (2003). Reproduced from http://www.stuartbell.co.uk/ravens.html, accessed 23rd August, 2011. Reprinted with permission. 20

Figure 3. Abstract item difficulty index. 51

Figure 4. Verbal item difficulty index. 51

Figure 5. Estimated marginal A_{total} means for ages 16 through 58 years. 54

Figure 6. Estimated marginal V_{total} means for ages 16 through 58 years. 54