Multivariate analysis on the heritability of reading ability across the distribution

Introduction

Reading and spelling are necessary for everyday functioning, facilitating not only educational attainment but also greater emotional regulation. Several cognitive abilities are associated with reading and spelling, all shown to be highly heritable. However, estimates of genetic influences on continuously distributed variables are often assumed to be consistent across the distributions[2]. In this study, I seek to investigate whether these cognitive processes show the same genetic relations in poorer and stronger readers.

Data

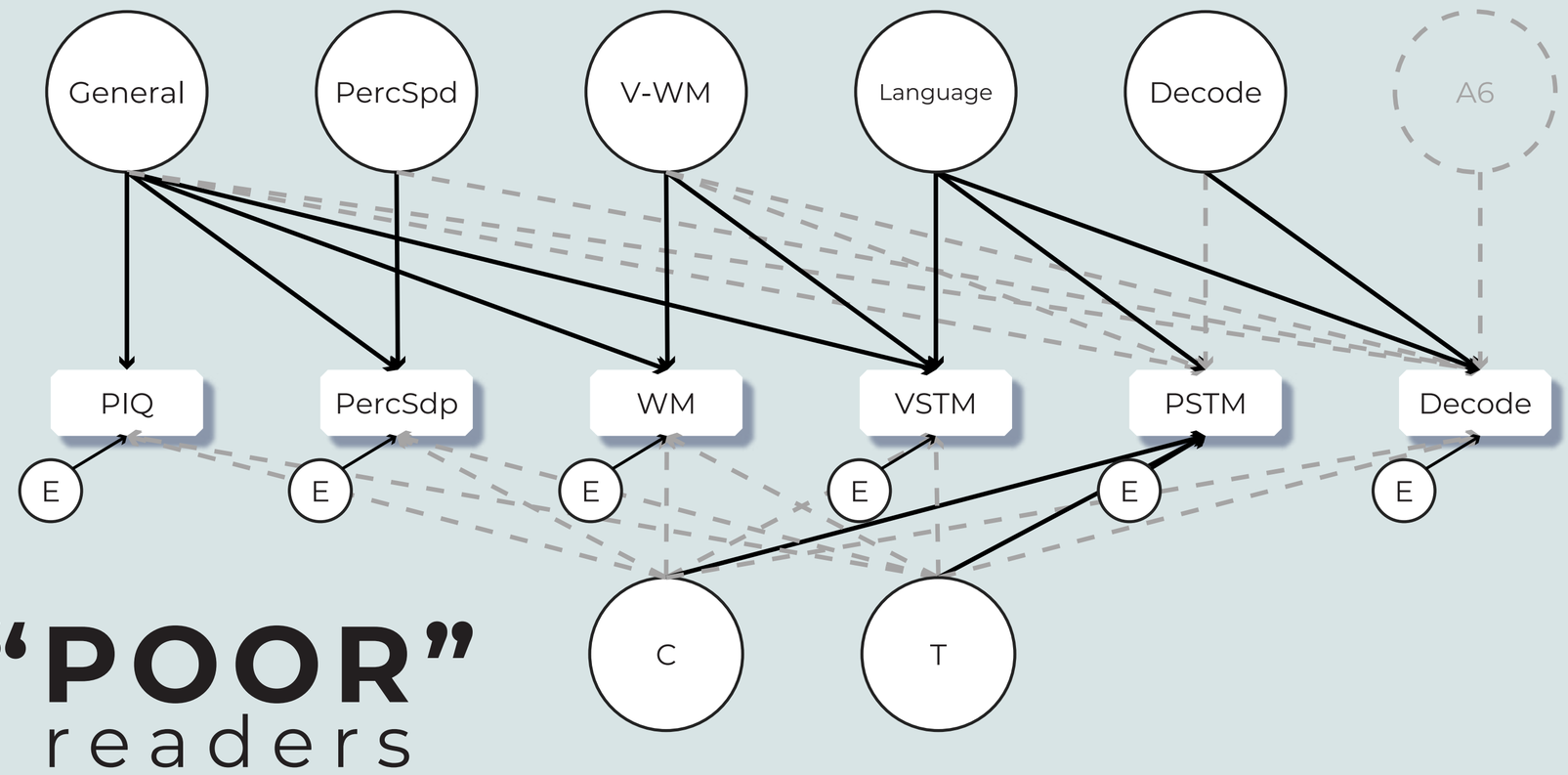
The data consists of twins and their siblings recruited through The Brisbane Adolescent Twin Study[1]. The analyses use 1,877 twins and siblings from 932 families.

Methods

The sample was split into "good" and "poor" readers based on a composite* reading measure. For both samples, a multivariate Cholesky ACTE decomposition was used to partition phenotypic variance in the six variables measuring different cognitive abilities into components corresponding to additive genetic effects (A), shared environment (C), and unique environment (E). An exploratory method in this study involves estimating the effect of twin-specific environment (T). Basic assumptions for the Classical Twin Design were tested.

*Regular reading, irregular reading, regular spelling, and irregular spelling

Results



"POOR" readers

Main finding: Greater genetic covariance between phonological decoding and memory variables.

Variable	h^2	c^2	t^2	e^2
PIQ	**0.73** [0.66 – 0.83]	0.01 [0.00 – 0.05]	0.02 [0.00 – 0.11]	**0.24** [0.19 – 0.30]
PercSpd	**0.69** [0.63 – 0.79]	0.00 [0.00 – 0.00]	0.00 [0.00 – 0.03]	**0.30** [0.24 – 0.38]
WM	**0.35** [0.27 – 0.50]	0.01 [0.00 – 0.05]	0.01 [0.00 – 0.06]	**0.63** [0.54 – 0.72]
VSTM	**0.41** [0.33 – 0.56]	0.01 [0.00 – 0.09]	0.00 [0.00 – 0.00]	**0.58** [0.46 – 0.66]
PSTM	**0.38** [0.22 – 0.56]	**0.21** [0.03 – 0.34]	**0.14** [0.03 – 0.25]	**0.27** [0.23 – 0.32]
Decode	**0.48** [0.32 – 0.64]	**0.11** [0.01 – 0.23]	0.03 [0.00 – 0.12]	**0.38** [0.29 – 0.45]

	PIQ	PercSpd	WM	VSTM	PSTM
Phenotypic correlation	**0.14** [0.07 – 0.20]	**0.07** [0.00 – 0.14]	**0.16** [0.10 – 0.21]	**0.13** [0.08 – 0.18]	**0.25** [0.20 – 0.30]
Genetic correlation	**0.10** [-0.14 – 0.28]	**0.13** [-0.12 – 0.37]	**0.32** [0.02 – 0.64]	**0.44** [0.27 – 0.74]	**0.22** [-0.08 – 0.46]

Note: Genetic and phenotypic correlations between phonological decoding and other variables.

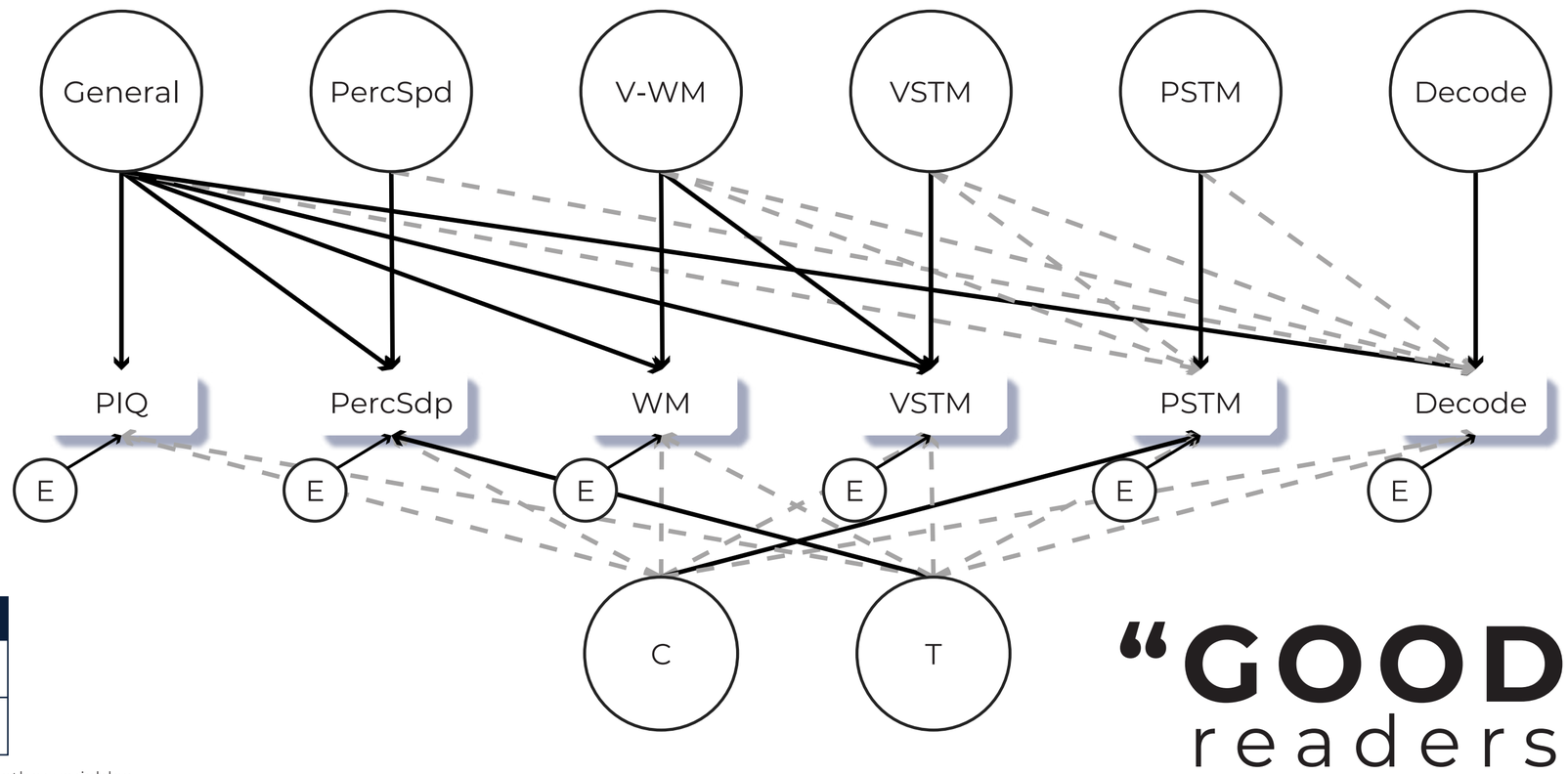
"GOOD" readers

Main finding: Better readers show a greater dependency on general cognitive abilities.

Variable	h^2	c^2	t^2	e^2
PIQ	**0.64** [0.57 – 0.74]	0.01 [0.00 – 0.06]	0.05 [0.00 – 0.13]	**0.30** [0.24 – 0.37]
PercSpd	**0.44** [0.18 – 0.58]	0.00 [0.00 – 0.07]	**0.15** [0.04 – 0.33]	**0.40** [0.29 – 0.50]
WM	**0.31** [0.21 – 0.42]	0.01 [0.00 – 0.02]	0.02 [0.00 – 0.09]	**0.67** [0.58 – 0.77]
VSTM	**0.46** [0.38 – 0.59]	0.01 [0.00 – 0.00]	0.02 [0.00 – 0.10]	**0.52** [0.42 – 0.59]
PSTM	**0.22** [0.09 – 0.38]	**0.38** [0.27 – 0.49]	0.03 [0.00 – 0.15]	**0.37** [0.32 – 0.43]
Decode	**0.48** [0.40 – 0.56]	0.01 [0.00 – 0.07]	0.02 [0.00 – 0.07]	**0.49** [0.42 – 0.56]

	PIQ	PercSpd	WM	VSTM	PSTM
Phenotypic correlation	**0.15** [0.08 – 0.20]	**0.04** [-0.02 – 0.10]	**0.13** [0.08 – 0.17]	**0.14** [0.09 – 0.19]	**0.19** [0.14 – 0.24]
Genetic correlation	**0.32** [0.13 – 0.48]	**0.11** [-0.07 – 0.40]	**0.20** [0.02 – 0.38]	**0.23** [0.04 – 0.39]	**0.30** [0.13 – 0.48]

Note: Genetic and phenotypic correlations between phonological decoding and other variables.



Discussion

Findings indicate variation in the magnitude of genetic effects on reading ability across the distribution, with noticeable differences in the heritability of perceptual speed and PSTM. Consistent with previous research, phenotypic and genetic correlations for general cognitive ability were greater for better readers[3]. An exploratory method reveals a possible twin-specific environment for PSTM for poorer readers, which might arise from poorer linguistic home environment in twins[4]. For better readers, a twin-specific effect for perceptual speed was found - a finding which will be investigated and discussed further.

References

1. Wright, M. J., & Martin, N. G. (2004). Brisbane Adolescent Twin Study: Outline of study methods and research projects. *Australian Journal of Psychology*, *56*(2), 65–78.
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4. Trombetta, T., Brustia, P., Curti, L., Caldarera, A. M., Gerino, E., & Rollè, L. (2019). Twins' and Singletons' Linguistic Environment: A Systematic Review. *Frontiers in Psychology*, *10*, 2005–2005.

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