The Etiology of the Association between Mental Development and Working Memory in Toddlerhood

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Introduction

- Mental development (MD) and working memory (WM) are related but not isomorphic (Ackerman, Beier, & Boyle, 2005).
- The association between MD and WM in adolescence is due solely to genetic factors (Luciano et al., 2001).
- No studies, however, have examined this link in early childhood—a time when MD is substantially influenced by the shared environment in addition to genetics.
- It is possible, therefore, the factors that contribute to the association between MD and WM in early childhood may differ from those in adolescence.
- This work can help to inform whether MD and WM have common underlying biological bases.

Methods

Sample

- 311 same-sex monozygotic (MZ=144) and dizygotic (DZ=167) twin pairs assessed within two weeks of their second and third birthdays.
- Zygosity was determined via DNA analyses using DNA obtained from cheek swab samples.
- Approximately equal numbers of males and females (53% male).

Measures

- MD was assessed with the Mental Scale of the Bayley Scales of Infant Development II (Bayley, 1993). (See Figure 1).
  - The Mental Scale assesses memory, habituation, number concepts, classification, generalization, problem solving, language, and social skills and yields a Mental Development Index (MDI). The MDI is a normalized standard score with a mean of 100 and a standard deviation of 15.
- WM was assessed with the Visually Cued Recall Task (VCR; Zelazo et al., 2002). (See Figure 2).
  - The VCR is a combination of a pictorial memory span task and a delayed response task. Participants are required to recall a sequence of pictorial items presented by the experimenter.

Results

Phenotypic Associations

- MD was substantially stable across age (r=.53). There was a significant longitudinal association from MD at age 2 to WM at age 3 (r=.39) and a concurrent association between the phenotypes at age 3 (r=.45) all p<.01.

Twin Intraclass and Cross-trait Correlations

- For all correlations (Figure 3), the MZ twin correlations exceeded DZ, suggesting genetic influences.

Data Analysis

- A multivariate Cholesky decomposition model was used to estimate genetic (A), shared environmental (C), and nonshared environmental (E) contributions to variance for MD and WM and to the covariance between the two domains (See Figure 4).
- This model decomposes the variance into effects common to all three measures (A1, C1, E1); effects on MD and WM at age 3 independent of MD at age 2 (A2, C2, E2); and effects on WM at age 3 that are independent of MD at both ages (A3, C3, E3).
- Diagonal paths represent the genetic and environmental covariances among phenotypes.

Model-Fitting Results

- Figure 4 presents the results from the full model. Solid paths were significant.
- All measures were influenced by genetic, shared environmental, and nonshared environmental factors.
- As indicated by the significant A1 and C1 paths, there are genetic and shared environmental effects common to all three measures.
- After accounting for MD at age 2, there was no significant covariance between MD at age 3 and WM at age 3, nor were there significant genetic and shared environmental influences on WM independent of MD at age 2.
- The covariance paths for the nonshared environmental influences were nonsignificant, indicating that nonshared environmental effects are specific to MD at both ages and to WD at age 3.
- Figure 5 presents the estimates of genetic and shared environmental and nonshared environmental variances for each domain.

Conclusions

- MD and WM at the level of etiology are very similar, and differ only due to nonshared environmental influences that are unique to each construct.
- Although genetics account for the relation between MD and WM in adolescence (Luciano et al., 2001), both genetic and shared environmental factors underlie the association between these constructs in toddlerhood.
- These findings highlight change in the factors that underlie the association between MD and WM across development and can inform avenues for interventions in early childhood.

Acknowledgements

The Boston University Twin Project (BUTP) is supported by grants MH062375 and HD08435 to Dr. Saudino. The twins’ and families’ participation is gratefully acknowledged.