THE DEVELOPMENT OF COGNITIVE FUNCTIONING INDICES IN EARLY CHILDHOOD: FINDINGS FROM GROWING UP IN NEW ZEALAND

COMPASS Seminars 2019

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The Development of Cognitive Functioning Indices in Early Childhood

Outline

1. Background
2. The Growing up in New Zealand study (GUiNZ)
3. Methods
4. Results
5. Conclusion
1. Background

- Early childhood years: Rapid changes in development of cognitive abilities $\rightarrow$ brain development, environmental input

- Brain development prolonged process, important changes taking place during the preschool years (Mungas et al., 2013)

- Early cognitive disadvantages associated with poorer behavioural, socio-emotional and academic outcomes later in life (Beitchman et al., 1996)
1. Background

- Limitations of previous studies: Focus on narrow age ranges; few attempts to observe developmental trajectories of cognitive functioning; cross-sectional

- Challenges of longitudinal assessment of the development of cognitive constructs, i.e.
  - Tasks that are developmentally appropriate for one age are not necessarily appropriate for another
  - Great variability in child performance during early periods in development (Best & Miller, 2010)
  - Lack of established measures that are suitable across the entire age range (Mungas et al. 2013)
  - Funding and time restrictions in large population-based longitudinal studies
1. Background

Aims and objectives

• Developing cognitive composite indices (CCIs) at 9 months, 2 years and 4.5 years
  → Using data from an up-to-date longitudinal population-based New Zealand birth cohort: Growing Up in New Zealand study

• Investigation of trajectories of cognitive functioning in early childhood

• Identification of predictors promoting or hindering cognitive abilities
2. The Growing up in New Zealand Study (GUiNZ)

- A longitudinal study following a group of New Zealand children, in the context of their families, from pre-birth to early adulthood
  - 6846 babies (52% male)
  - born in 2009/2010
  - interviews in homes antenatally, at 9 months, and 2 years, 4.5 years, 8 years
What were the GUINZ recruitment areas?
Research domains and themes for GUiNZ

Figure 02. Domains and Themes informing *Growing Up in New Zealand*
Why create a Cognitive Composite Index (CCI)?

• Global picture → global level of delay
• Different cognitive measures/cognitive abilities at each data collection wave
• Longitudinal study: Examine cognitive trajectories over time
• Avoids problem of multiple testing
• Accounting for interrelations between cognitive outcomes
3. Methods

Measures: Cognitive Outcomes

- **9 months:** Pre-linguistic communication (Mac Arthur CDI: Words and Gestures); Verbal communication (CSBS); Motor milestones (parent-report)
- **2 years:** Expressive verbal communication (Mac Arthur CDI-II); Inhibitory control, Attention, Motor abilities (Stack & Topple interaction task)
- **4.5 years:** Receptive language (PPVT); Phonological awareness (DIBELS); Executive control (Luria Clapping Task); Writing, Numeracy and Symbols (Who am I? Name and Numbers task, Count up, Count down task)
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- Mixture of continuous and categorical variables
- → age-adjustment if correlation with age
Missing data pattern:

- Of 6074 cases, 1667 (27%) complete cases
- Cases >50% missing data (n=491) deleted beforehand
- 1.5% - 42.2% missing data per variable

% Missing data in cognitive outcomes

- 13% missingness
Missing data pattern:

- Little’s MCAR test: $p < .001 \rightarrow$ data not missing completely at random
- Missing at random: Variety of variables associated with variables with missing data, differences between complete cases and cases with missing data
- Auxiliary variables (sociodemographic and behavioural data, low to moderate correlations)
- Categorical and continuous variables, partially skewed
Multivariate Imputation by Chained Equations (MICE)

- Software imputing incomplete multivariate data by fully conditional specification approach (Van Buuren, 2007)
- R package (mice) in RStudio
- Bodner’s rule of thumb: number of imputations in accordance to percentage of incomplete cases (White et al., 2011) → 73 imputations with 10 iterations
Problem

Combining multiple imputation and factor analysis due to the issue of combining the results from different imputed data sets \(\rightarrow\) merely averaging not appropriate

Solution

Nassiri et al. (2018): first estimate the covariance matrix from imputed data sets using *Rubin’s rules* (Rubin, 2004)
Problem

• Combining multiple imputation and factor analysis due to the issue of combining the results from different imputed data sets → merely averaging not appropriate

Solution

• Nassiri et al. (2018): first estimate the covariance matrix from imputed data sets using *Rubin’s rules* (Rubin, 2004)

• Performing factor analysis on a single combined matrix working on the parameter level

• Implemented R package *mifa* to estimate the covariance matrix for each imputed dataset

• → *mifa* function adjusted for estimated mixed correlation matrix used for analysis
4. Results

Creating a cognitive composite index at 9 months

Non-verbal communication  Motor abilities  CSBS Emotion  CSBS Communication  CSBS Expression  CSBS Comprehension

CCI

Principal axis factoring with promax rotation
Creating a cognitive composite index at 9 months

One-factor solution ($\omega = .76$)
4. Results

Creating a cognitive composite index at 2 years

Principal axis factoring with promax rotation
4. Results

Creating a cognitive composite index at 2 years

Two-factor solution ($\omega_1 = .81; \omega_2 = .65$)
Creating a cognitive composite index at 4.5 years

4. Results

Principal axis factoring with promax rotation
4. Results

Creating a cognitive composite index at 4.5 years

One-factor solution ($\omega = .74$)
Creating a cognitive composite index at 2 years

4. Results: Complete Cases

One-factor solution
\( \omega = .74 \)
Validity of CCIs

Correlation with:

- **Pragmatic language/early literacy**: mother-report at 4.5 years
- **School readiness**: mother-report at 6 years

### Table 3. Correlation of CCIs with literacy and school readiness

<table>
<thead>
<tr>
<th>CCI</th>
<th>Literacy (4.5 years)</th>
<th>School readiness (6 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCI 9 months</td>
<td>0.13** (.12**)</td>
<td>0.02** (.05)</td>
</tr>
<tr>
<td>CCI 2 years F1</td>
<td>0.04* (.02)</td>
<td>0.01** (-.02)</td>
</tr>
<tr>
<td>CCI 2 years F2</td>
<td>0.11** (-)</td>
<td>0.03** (-)</td>
</tr>
<tr>
<td>Verbal communication 2 years</td>
<td>0.35** (.34**)</td>
<td>0.11** (.10**)</td>
</tr>
<tr>
<td>CCI 4.5 years</td>
<td>0.27** (.24**)</td>
<td>0.12** (.15**)</td>
</tr>
</tbody>
</table>

*Note.* Correlation for complete cases in brackets.
Conclusion

• Identification of valid CCIs at 9 months and 4.5 years
• At age 2 years, only the language component related to later literacy and school readiness → may partially reflect the measures used
• Results of complete cases analysis vary at 2 years → largest amount of missing data
• CCIs provides the opportunity to potentially examine early cognitive trajectories along with factors that promote or hinder cognitive functioning in early childhood

Results of imputed data with high rates of missingness have to be interpreted with caution
Use of CCIIs for further analysis

CCI

9 months

CCI

2 years

CCI

4.5 years
1. Categorical indices

Trajectories/Movement:

- Stable
- Increase
- Decline

9 months  2 years  4.5 years
Outlook

2. CCIs as latent constructs in SEM/path modelling

- Receptive language
- Phonological awareness
- Count Up task
- Name Task
- Name Task
- Executive control
Thank you!

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