Measuring Self-Regulatory Development from Kindergarten to Fifth Grade: Longitudinal Psychometrics with Alignment Optimization

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Self-Regulation

A person’s ability to manage their own thoughts, feelings, and actions.
- Important for early education and school readiness.
- Manifest behaviors and cognitive capacities.

Effortful Control (EC):
- Temperament theory (Rothbart & Bates, 2006):
  - Attentional Focusing, Inhibitory Control
- Indirectly assessed by adult (or self) report
- Theorized as a (relatively) stable individual trait
**Objective:**
Examine children’s development of EC across elementary school

**RQ1.** What is the latent factor structure of EC from KG to 5th grade, as measured by teacher reports in the ECLS-K?

**RQ2.** Is there evidence to support the developmental scaling of EC under the condition of approximate measurement invariance?

**RQ3.** What are the typical pattern(s) of stability and change in teacher-rated EC from KG to 5th grade?
Data

- Early Childhood Longitudinal Study, Kindergarten Class of 2010-2011 (ECLS-K)
  - Analytic Sample: \( N = 10,345 \)
  - Psychometric calibration sample: \( N = 7,000 \)

- EC: Teacher reports of *Inhibitory Control* and *Attentional Focusing*
  - Children’s Behavior Questionnaire (CBQ)
  - Temperament in Middle Childhood Questionnaire (TMCQ)

<table>
<thead>
<tr>
<th>Wave</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
<td>KG, F</td>
<td>KG, S</td>
<td>1, F</td>
<td>1, S</td>
<td>2, F</td>
<td>2, S</td>
<td>3, S</td>
<td>4, S</td>
<td>5, S</td>
</tr>
</tbody>
</table>

CBQ  
TMCQ
**Data**

**CBQ (Rothbart et al., 2001)**
- Ages 3-7
- 7 response categories
  - 1= extremely untrue
  - 4= neither true nor untrue
  - 7= extremely untrue

**Attentional Focusing (6 items)**
- “Is easily distracted when listening to a story” R
- “When practicing an activity, has a hard time keeping his/her mind on it” R

**Inhibitory Control (6 items)**
- “Is good at following directions”
- “Can easily stop an activity when s/he is told ‘no’”
- “Can wait before entering into new activities if s/he is asked to”

**TMCQ (Simonds & Rothbart, 2004)**
- Ages 7-10
- 5 response categories
  - 1= almost never true
  - 3= sometimes true, sometimes untrue
  - 5= almost always true

**Attentional Focusing (6)**
- “Is easily distracted when listening to a story” R
- “When working on an activity, has a hard time keeping her/his mind on it” R

**Inhibitory Control (7 items)**
- “Is good at following directions”
- “Can stop him/herself when s/he is told to stop”
- “Has an easy time waiting”
Methods: Confirmatory Factor Analyses (RQ1)

1.1

EC

i1
i2
i3
i4
i5
i6
i12

1.2

EC

i1
i2
i3
i4
i5
i6

1.3

AF

i1
i2
i3
i4
i5
i6

IC

i7
i8
i12

1.4

EC

i1
i2
i6
i7
i8
i12

AF

i12
## RQ1: CFA Results

<table>
<thead>
<tr>
<th>Model</th>
<th>CBQ (waves 1, 2, 4)</th>
<th>TMCQ (waves 6-9)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\chi^2$(df)</td>
<td>CFI</td>
</tr>
<tr>
<td>1-factor (1.1)</td>
<td>2367 (55)</td>
<td>0.85</td>
</tr>
<tr>
<td>1-factor, res. cov. (1.2)</td>
<td>518 (38)</td>
<td>0.97</td>
</tr>
<tr>
<td>2-factor (1.3)</td>
<td>1828 (53)</td>
<td>0.88</td>
</tr>
<tr>
<td>Bifactor (1.4)</td>
<td>605 (42)</td>
<td>0.96</td>
</tr>
</tbody>
</table>
Results: Confirmatory Factor Analysis of CBQ (RQ1)

CBQ Data:
Waves 1, 2, 4

Effortful Control
\( \alpha = .91 \quad \omega = .87 \)

i1: Hard time keeping mind on activity
i2: Moves tasks without completing
i3: Strong concentration coloring, drawing
i4: Very involved for long periods, building, putting together
i5: Easily distracted listening to story
i6: Sometimes absorbed in book for long time
i7: Can wait entering new activities if asked
i8: Plans for new activities to have what is needed
i9: Trouble sitting still when told (e.g., listening to story)
i10: Good at following instructions
i11: Approaches ‘risky’ places cautiously
i12: Can easily stop activity when told ‘no’
Results: Confirmatory Factor Analysis of TMCQ (RQ1)

TMCQ Data: Waves 6, 7, 8, 9

Effortful Control

\[ \alpha = .95 \quad \omega = 1.0 \]

- \( i1 \): Easily distracted when listening to story
- \( i2 \): Can stop when told to stop
- \( i3 \): Looks around room when doing schoolwork
- \( i4 \): Can stop doing things too quickly
- \( i5 \): Working on activity, has hard time keeping mind on it
- \( i6 \): Has an easy time waiting
- \( i7 \): Has a hard time paying attention
- \( i8 \): Has hard time waiting turn to talk when excited
- \( i9 \): Needs to be told to pay attention
- \( i10 \): Gets distracted trying to pay attention in class
- \( i11 \): Likes to plan carefully before doing something
- \( i12 \): Is good at following directions
- \( i13 \): Has hard time slowing down when rules say walk

\[ .82 \quad .79 \quad .82 \quad .86 \quad .85 \quad .87 \]

- Reverse-coded
- Not reverse-coded
- Common Content

\[
M = 0, \quad \text{Var} = 1
\]
Methods: Developmental Scaling of EC (RQ2)

Alignment Optimization Method (Asparouhov & Muthen, 2014, 2022)

- Multiple group model with approximate invariance
  - Emphasizes parameters that are “close enough” to invariant (parameter difference ≈ 0) over truly invariant (parameter difference = 0)
  - Optimizes fit function to obtain more parameters with trivial noninvariance and few parameters with large noninvariance
- Similar to Haberman IRT linking method (Pokropek et al., 2020; Robitzsch, 2020), and outperforms DIF detection with anchor items (DeMars, 2020)
Methods: Developmental Scaling of EC (RQ2)

Evaluation Criteria:

- Few noninvariant parameters:
  - < 25%, Muthen & Asparouhov, 2014; <29%, Flake & McCoach, 2018; 33%, Lai et al., 2021
  - More may be acceptable in some cases (100%, Marsh et al., 2018; 67%, Lai et al., 2021)

- Small degree of noninvariance (Lai et al., 2021, Luong & Flake, 2022)
RQ2: Developmental Scaling of EC

Procedure

1. Establish configural model for calibration sample (RQ1)

2. Use alignment method to obtain model with comparable factor means across time points (i.e., 7 “groups”)

3. Evaluate evidence of model fit from a secondary model with invariant items constrained to equality (Alignment-within-CFA [AwC], Marsh et al., 2018)

4. Generate longitudinal scores for full sample based on final (calibrated) model parameters
RQ2: Developmental Scaling of EC

Results

➢ Overall 12.86% noninvariance (9 out of 70 parameters)
  ○ 1 item fully noninvariant in both loadings and intercepts across all occasions
    ■ “Good at following directions”

➢ Small average parameter differences:
  ○ Loadings = .003 (.07%)
  ○ Intercepts = .024 (.49%)

➢ Confirmatory CFA using aligned parameter values
  ○ CFI > .97; SRMR, RMSEA ≤ .05
On average, children’s EC is better characterized by stability rather than change.

Model-estimated trend and 100 random cases

RQ3: Typical Trajectories of Stability & Change in EC
RQ4: Latent Growth Trajectories of EC

There is meaningful systematic heterogeneity among children’s trajectories of EC.

Class 1: 16%
Class 2: 46%
Class 3: 38%
Discussion

Decision points:

- Scaling of the EC items
- Focus on common content items
- Could not test the full AwC model with all 7 waves

Conclusions:

- EC is generally more stable than changing from KG to 5th grade.
- Teacher-reports of EC likely reflect the classroom context.
- Better measurement of classroom SR
Thank you!

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