

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

Emily Weiss

Boston University, Center on the Ecology of Early Development
emweiss@bu.edu

June 27, 2023

Modern Modeling Methods Conference

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)

Wave	1	2	3	4	5	6	7	8	9
Grade	KG, F	KG, S	1, F	1, S	2, F	2, S	3, S	4, S	5, S

 **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)

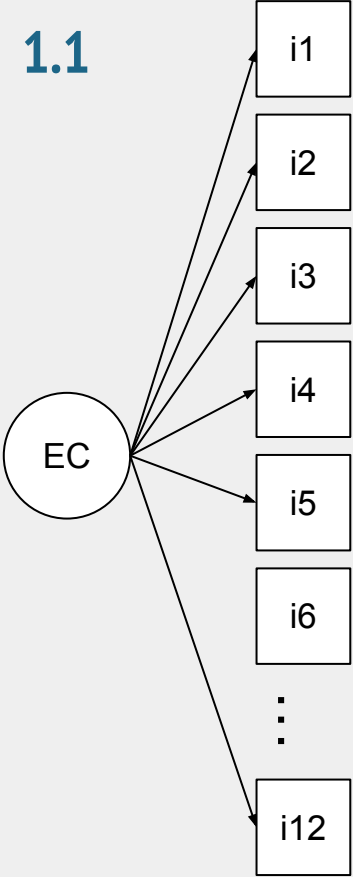
- "Is easily distracted when listening to a story" **R**
- "When working on an activity, has a hard time keeping her/his mind on it" **R**

Inhibitory Control (7 items)

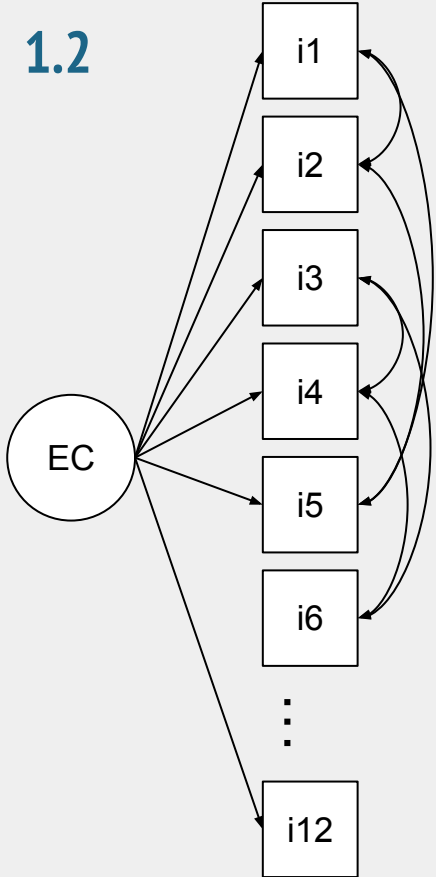
- "Is good at following directions"
- "Can stop him/herself when s/he is told to stop"
- "Has an easy time waiting"

Methods: Confirmatory Factor Analyses (RQ1)

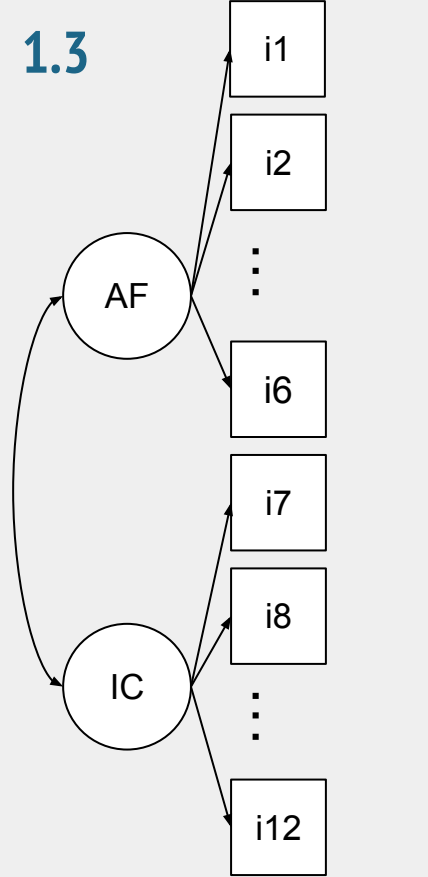
1.1



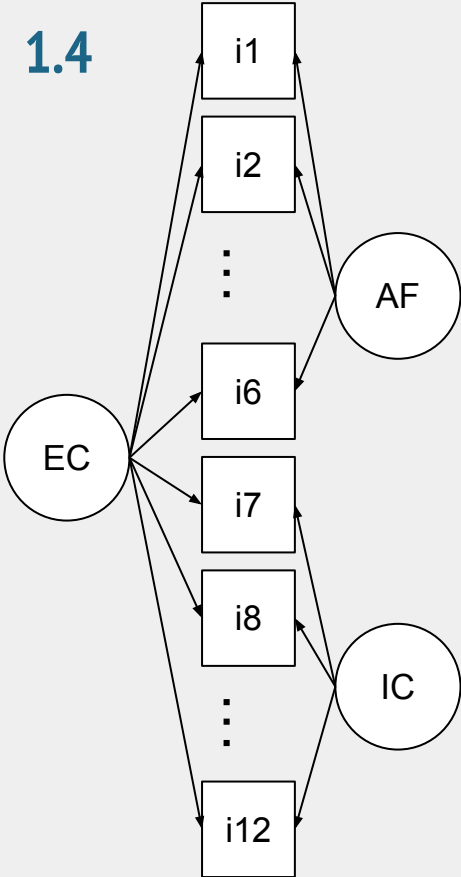
1.2



1.3



1.4



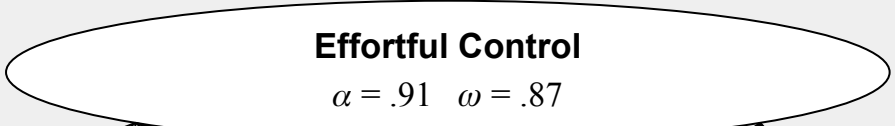
RQ1: CFA Results

Model	CBQ (waves 1, 2, 4)				TMCQ (waves 6-9)			
	χ^2 (df)	CFI	RMSEA	SRMR	χ^2 (df)	CFI	RMSEA	SRMR
1-factor (1.1)	2367 (55)	0.85	0.14	0.14	2582 (65)	0.92	0.1	0.06
1-factor, res. cov. (1.2)	518 (38)	0.97	0.07	0.03	521 (40)	0.98	0.06	0.07
2-factor (1.3)	1828 (53)	0.88	0.12	0.06	1753 (64)	0.94	0.09	0.04
Bifactor (1.4)	605 (42)	0.96	0.08	0.03	2299 (55)	0.93	0.11	0.20

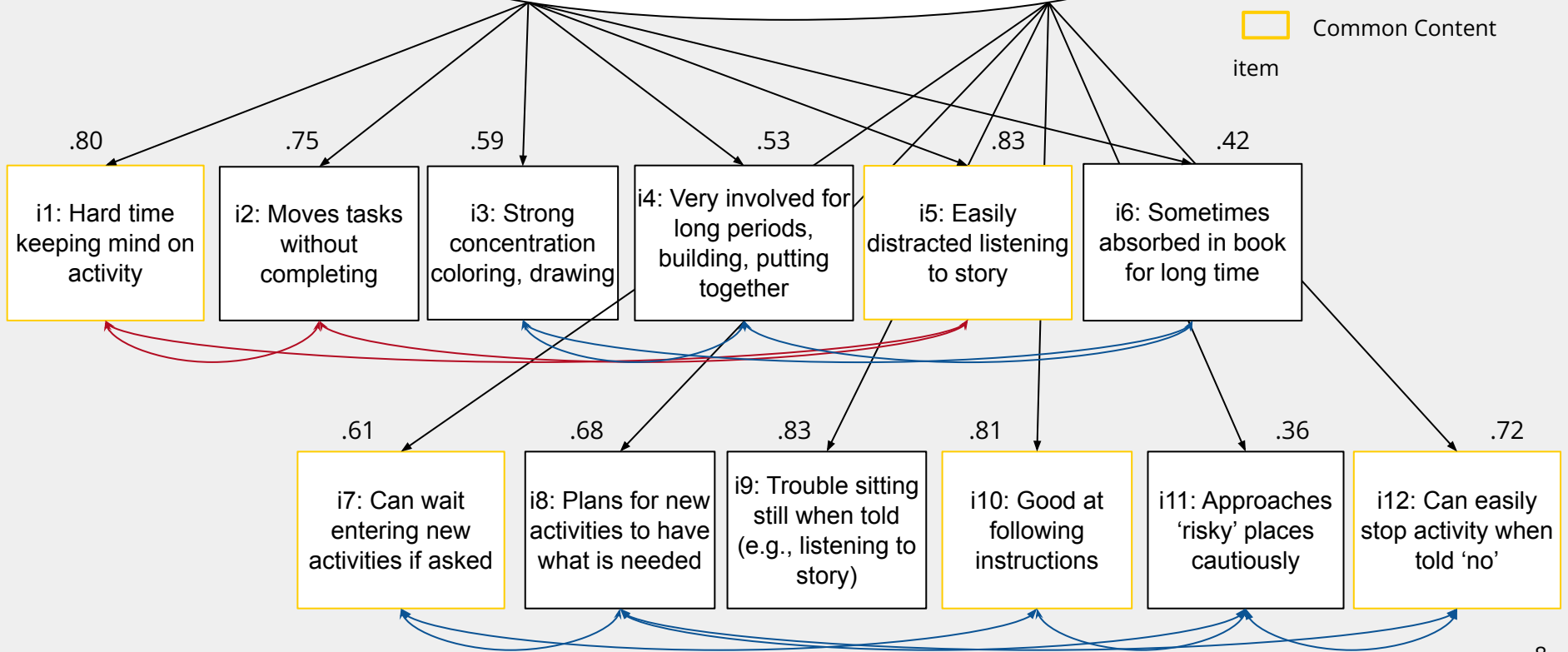
Results: Confirmatory Factor Analysis of CBQ (RQ1)

CBQ Data:
Waves 1, 2, 4

M = 0
Var = 1



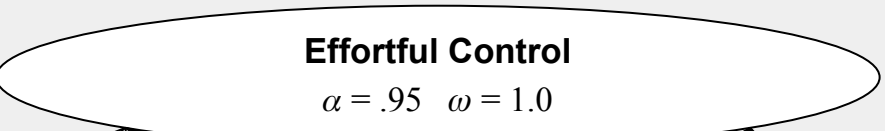
↔ Reverse-coded
↔ Not reverse-coded
□ Common Content item



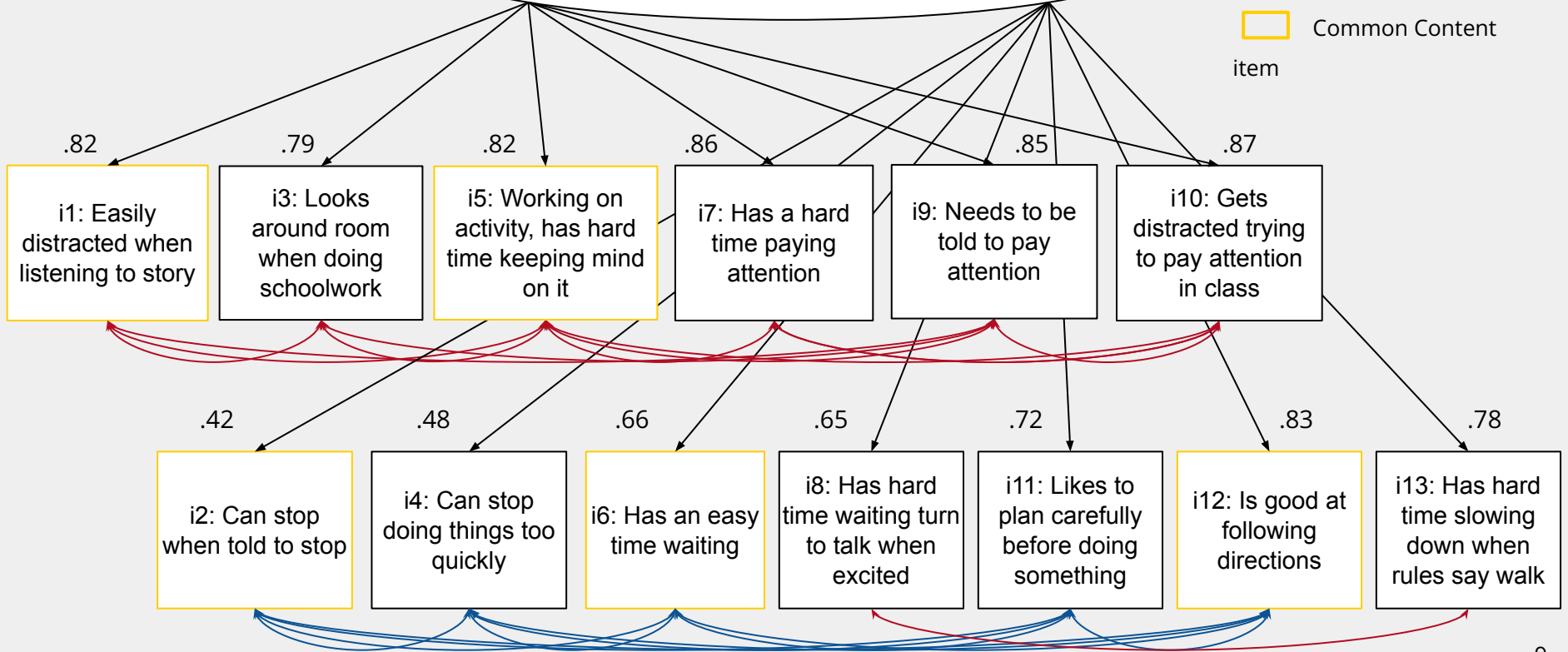
Results: Confirmatory Factor Analysis of TMCQ (RQ1)

TMCQ Data:
Waves 6,7,8,9

M = 0,
Var = 1



- ↔ Reverse-coded
- ↔ Not reverse-coded
- Common Content item



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

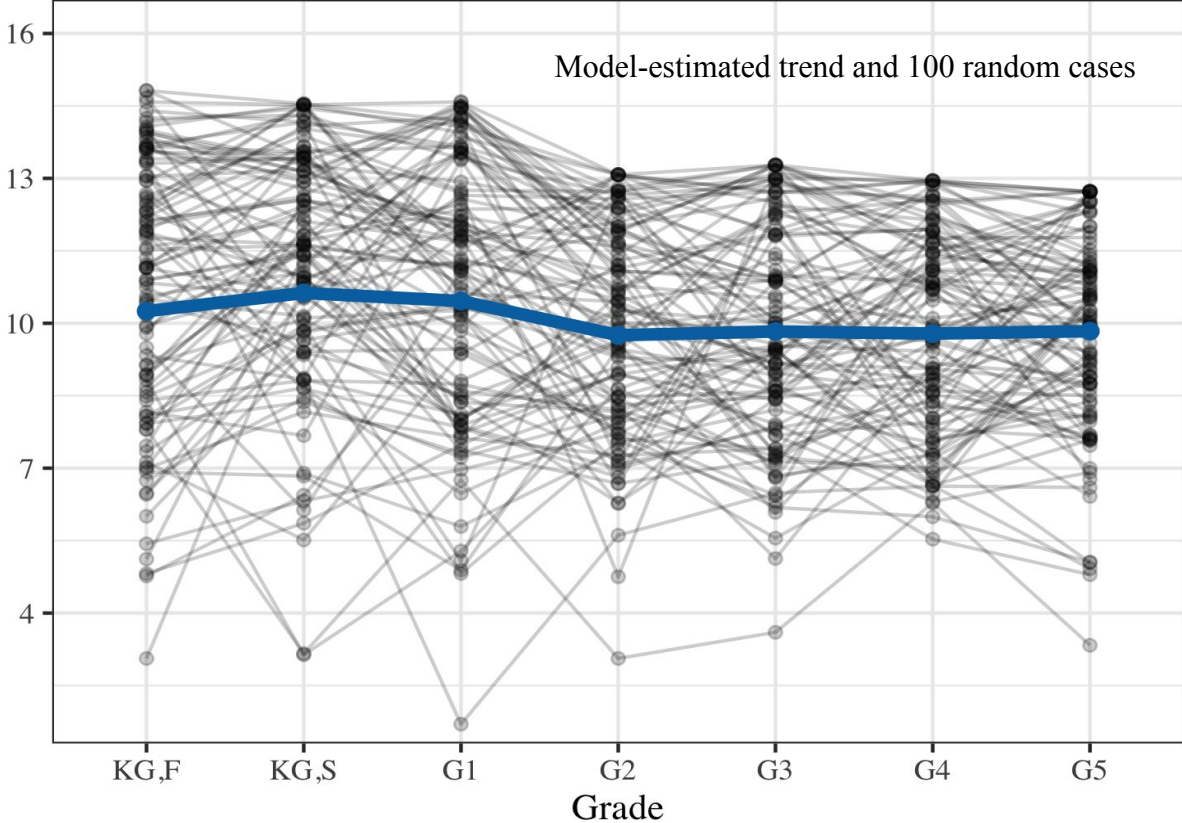
RQ2: Developmental Scaling of EC

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

RQ3: Typical Trajectories of Stability & Change in EC

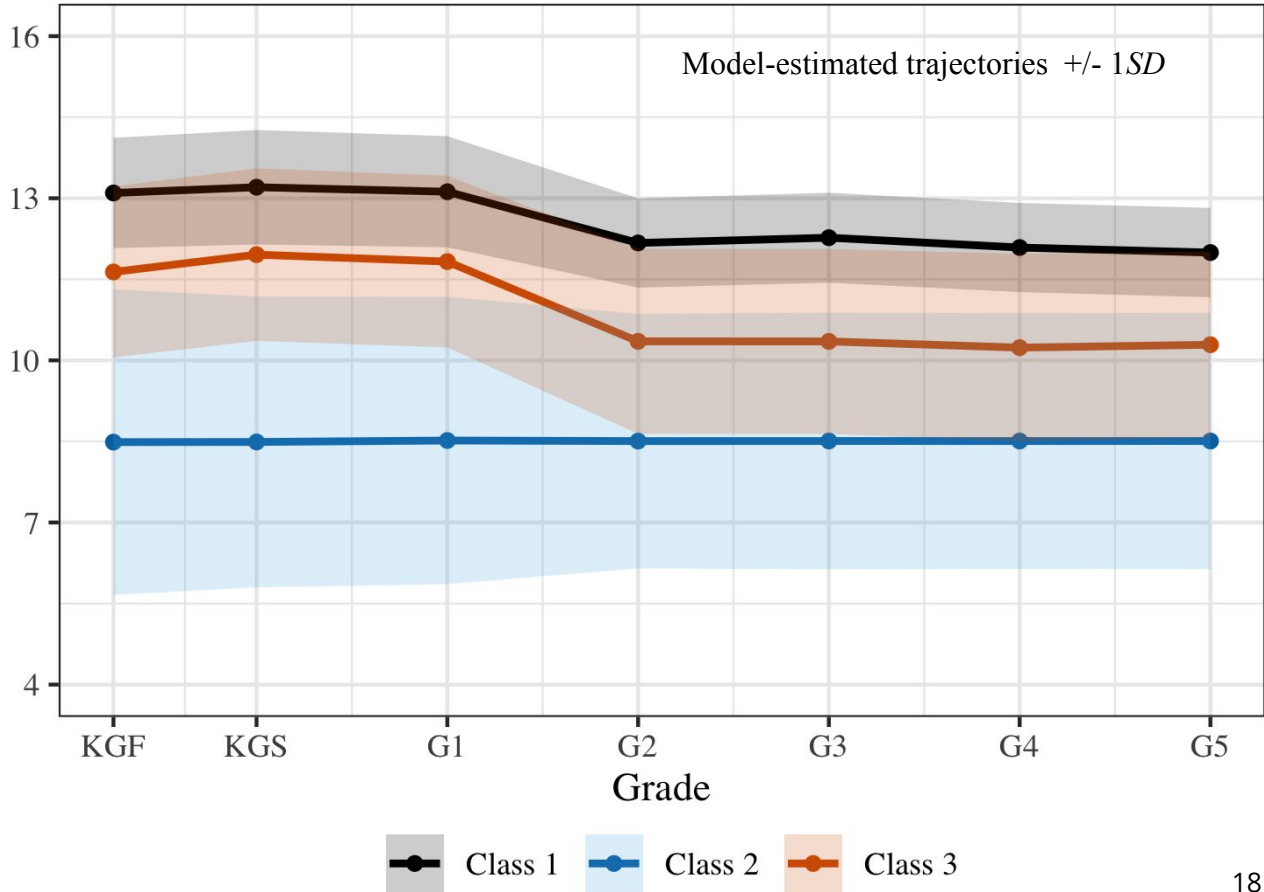
On average, children's EC is better characterized by stability rather than change



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

References

- Asparouhov, T., & Muthén, B. (2021). Residual structural equation models. Mplus Web Notes. http://statmodel.com/download/Asparouhov_Muthen_2021a.pdf
- Asparouhov, T., & Muthén, B. (2014). Multiple-Group Factor Analysis Alignment. *Structural Equation Modeling: A Multidisciplinary Journal*, 21(4), 495–508. <https://doi.org/10.1080/10705511.2014.919210>
- Curran, P. J., Howard, A. L., Bainter, S. A., Lane, S. T., & McGinley, J. S. (2014). The separation of between-person and within-person components of individual change over time: A latent curve model with structured residuals. *Journal of Consulting and Clinical Psychology*, 82(5), 879–894. <https://doi.org/10.1037/A0035297>
- DeMars, C. E. (2020). Alignment as an Alternative to Anchor Purification in DIF Analyses. *Structural Equation Modeling*, 27(1), 56–72. <https://doi.org/10.1080/10705511.2019.1617151>
- Pokropek, A., Lüdtke, O., & Robitzsch, A. (2020). An extension of the invariance alignment method for scale linking. *Psychological Test and Assessment Modeling*, 62(2), 305–334.
- Ram, N., Grimm, K. J., Gatzke-Kopp, L. M., & Molenaar, P. C. M. (2012). Longitudinal Mixture Models and the Identification of Archetypes. In B. Laursen, T. D. Little, & N. A. Card (Eds.), *Handbook of Developmental Research Methods* (pp. 481–499). The Guilford Press.
- Robitzsch, A. (2020). Lp Loss Functions in Invariance Alignment and Haberman Linking with Few or Many Groups Alexander. *Stats*, 3, 246–283. <https://doi.org/10.3390/stats3020009>
- Rothbart, M. K., Ahadi, S. A., Hershey, K. L., & Fisher, P. (2001). Investigations of Temperament at Three to Seven Years: The Children's Behavior Questionnaire. *Child Development*, 27(5), 1394–1408.
- Rothbart, M. K., & Bates, J. E. (2006). No Title. In N. Eisenberg, W. Damon, & R. M. Lerner (Eds.), *Handbook of Developmental Psychology: Social, Emotional, and Personality Development* (pp. 99–166). John Wiley & Sons, Inc.
- Simonds, J., & Rothbart, M. K. (2004). The Temperament in Middle Childhood Questionnaire (TMCQ): A computerized self-report instrument for ages 7-10. *Poster Session Presented at Occasional Temperament Conference, Athens, GA.*, 10.
- Tourangeau, K., Nord, C., Lê, T., Wallner-Allen, K., Vaden-Kiernan, N., Blaker, L., & Najarian, M. (2019). *Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ECLS-K:2011) User's Manual for the ECLS-K:2011 Kindergarten–Fifth Grade Data File and Electronic Codebook, Public Version (NCES 2019-051)*.
- Wickrama, K. A. S., Lee, T. K., O'Neal, C. W., & Lorenz, F. (2021). *Higher-Order Growth Curves and Mixture Modeling with Mplus* (2nd ed.). Routledge. <https://doi.org/10.4324/9781003158769>
- Zelazo, P. D., Blair, C. B., & Willoughby, M. T. (2017). *Executive Function : Implications for Education*. <https://ies.ed.gov/ncer/pubs/20172000/pdf/20172000.pdf>

Thank you!

emily.michelle.weiss@gmail.com
emweiss@bu.edu