Intraindividual educational research

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Outline

1. Processes and process-models
2. Student-reported learning experiences and teacher-reports
3. Student-reports and observed quality of student-teacher interaction
4. Student-reported learning experiences and objective measures
5. Conclusions

1. Processes

and process models

Development vs. process

Macro timescale:
Development
(months-years)

Meso timescale
(days-weeks)

Micro timescale
Process
(hours-lessons)

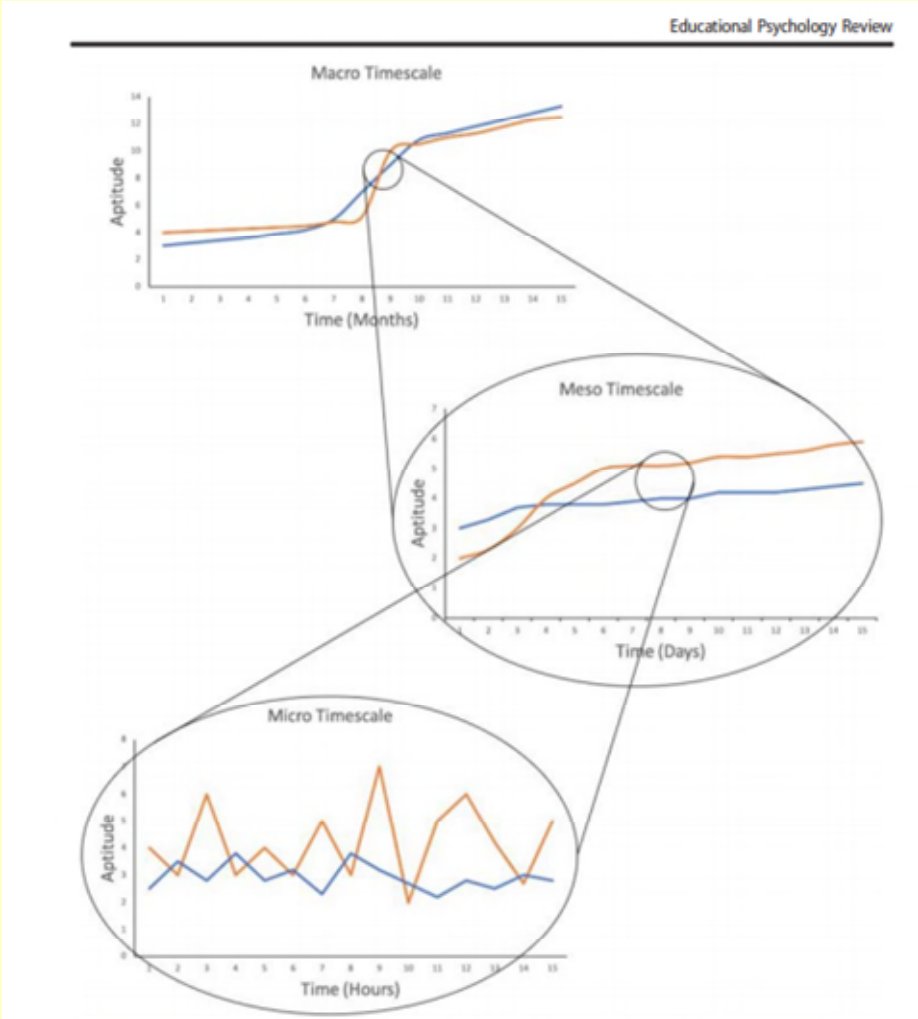


Fig. 2 Development of two fictional learners in a single aptitude over the course of months, days, and hours

Tetzlaff, L., Schmiedek, F., & Brod, G. (2021). Developing personalized education: a dynamic framework. *Educational Psychology Review.* doi: 10.1007/s10648-020-09570-w

How can we investigate educational processes?

A state is an experience in a situation

A process is a
* sequence of states, or
* a transformation of one state into another

The important questions to ask are
(1) What do teaching and learning processes look like?, and
(2) What effect does teaching have on learning processes?

Schmitz, B. (2006). Advantages of studying processes in educational research, *Learning and Instruction, 16,* 433-449.

How can we investigate educational processes?

We need to investigate the processes as they occur

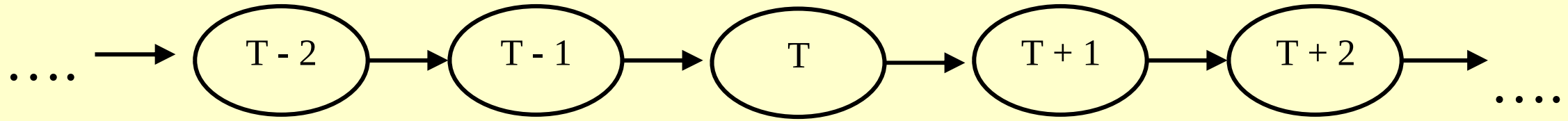
→ Intrapersonal, micro-longitudinal, within-person, ideographic research
→ Experience sampling, ecological momentary assessment (EDA), diaries
→ Reduces recall bias, increases contextual closeness

* Observations of individuals in real-time
* Ambulatory measurement of biophysiological measures, eye-tracking and gaze
* Trace data from computers

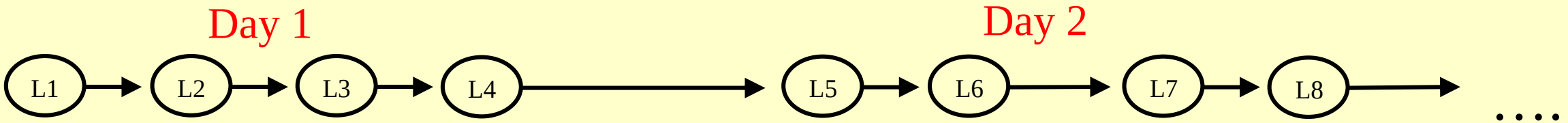
→ Huge interest in intraindivudal research in all social and medical sciences
→ Multimodal data getting easier to collect

Schmitz, B. (2006). Advantages of studying processes in educational research, *Learning and Instruction, 16,* 433-449.

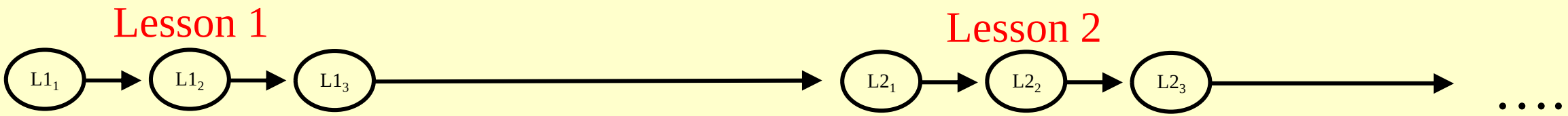
Time (chronological time vs. social time)



"Equal" spacing e.g., a diary response each evening



"Quite equal" spacing between lessons, but downtime between days



Beginning, middle and end of maths lesson, lessons further apart

Many concepts for change over time, e.g.,

* Stability = “carry over” or “inertia” from one time-point to the next

→ auto-regressive coefficients (association between observation at Time T and Time T-1)

* Variability = “ups and downs”

→ e.g., SD of observations (how different are the observations over time?)

* Instability = magnitude of fluctuations over time

→ e.g., Mean Sequential Squared Difference (MSSD) or RMSSD ($=\sqrt{\text{MSSD}}$)

* Volatility = “unpredictability” of change

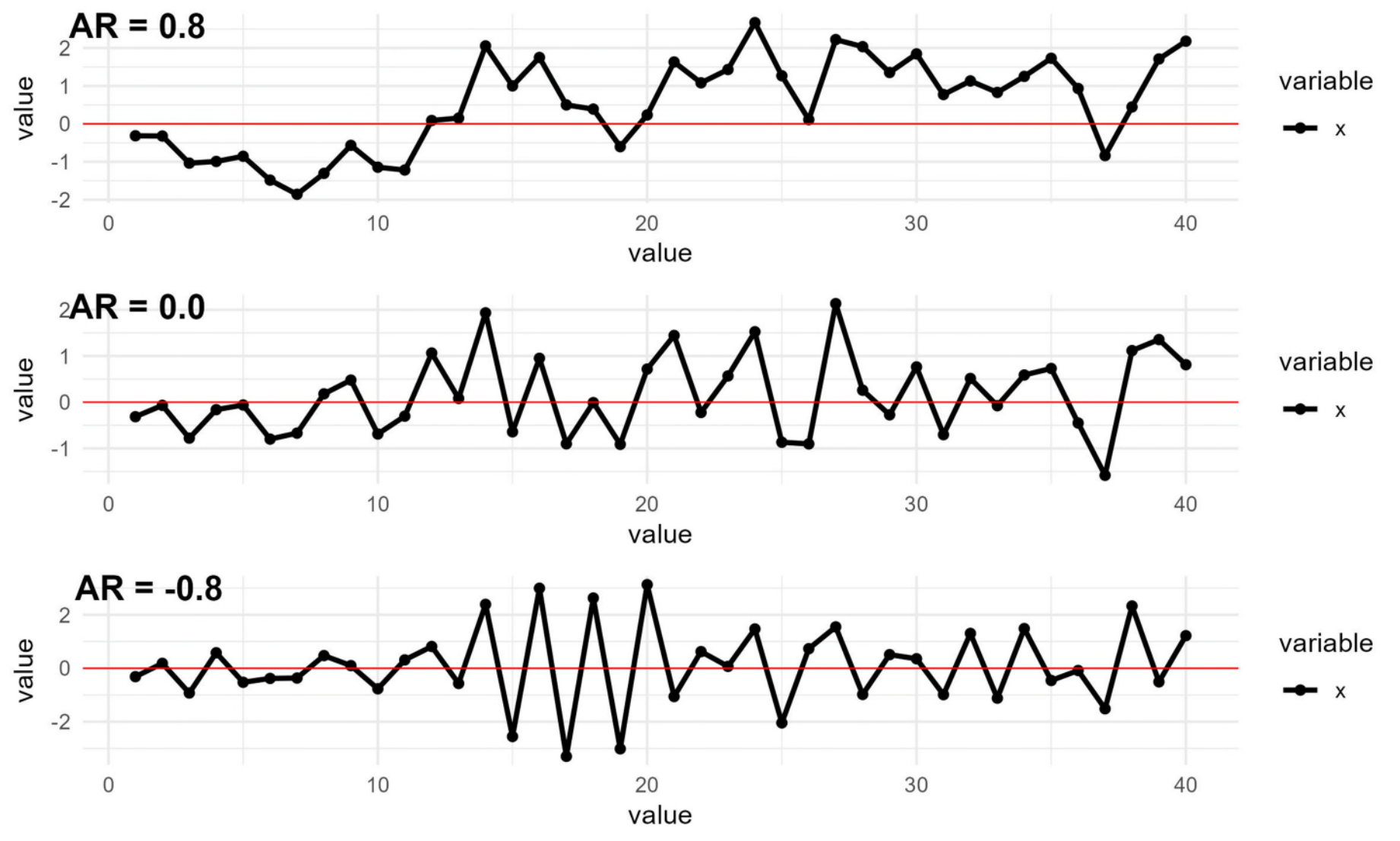
→ e.g., individual differences in residuals (unpredicted variance)

* Mean-trends = change in observations over time

→ e.g., β indicating increase or decrease

* Stationarity = no mean-trend over time, associations do not change over time

Stationary time-series with different auto-regressive parameters (0.8, 0.0, -0.8)



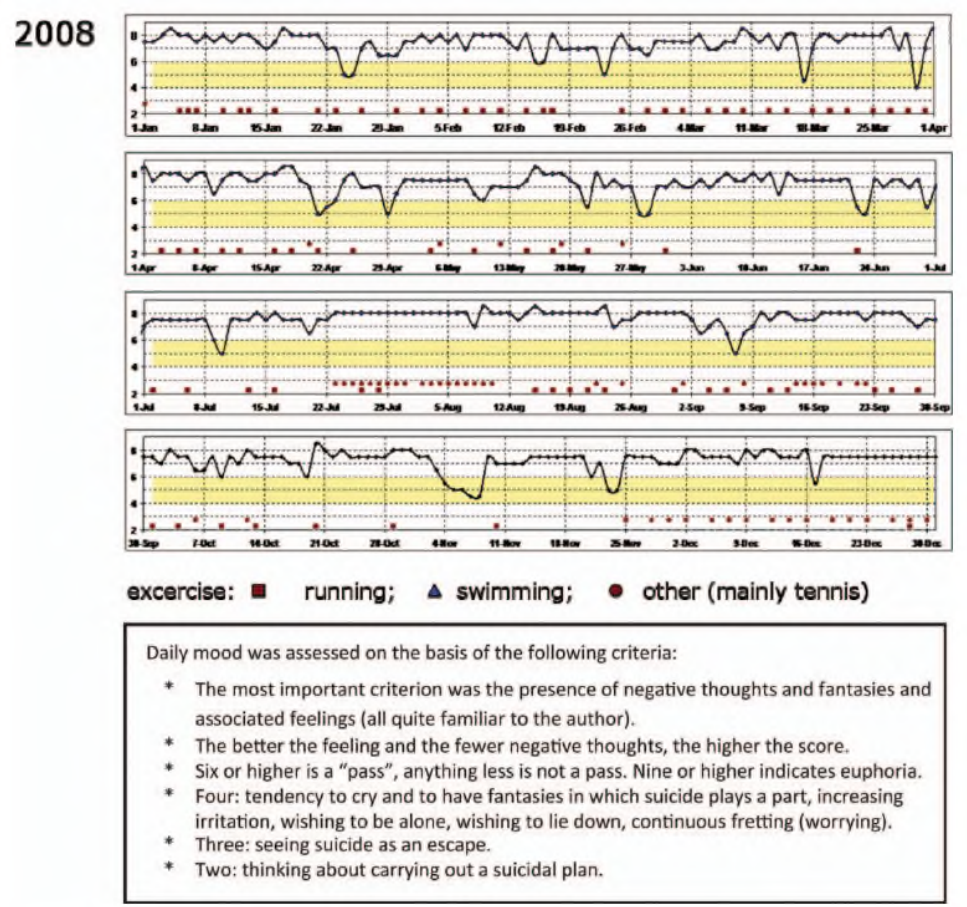
Small changes from one time-point to the next. Returns slowly to own baseline ("inertia")

Larger changes from one time-point to the next. Returns faster to own baseline.

Largest changes from one time-point to the next. Zig-zag / sawtooth pattern.

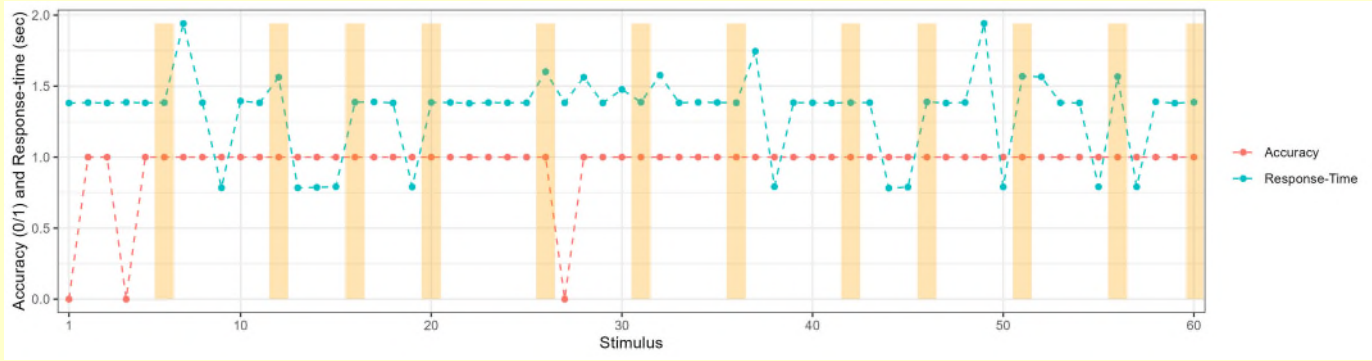
Time-series in practice

Days in years



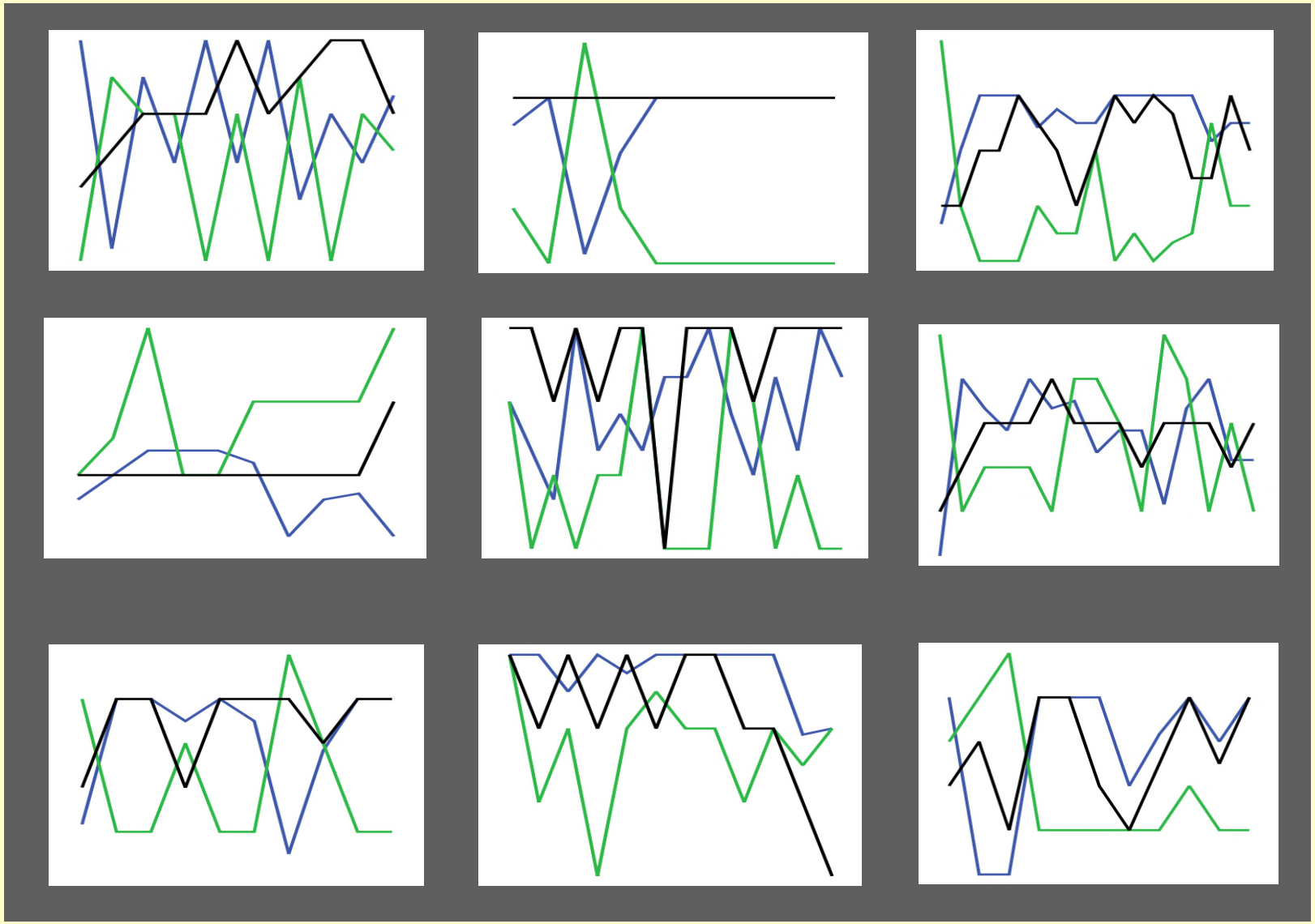
Daily mood for one year (2003-08; Groot, 2010)

Trials in an Executive Functioning session

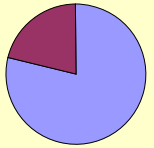


Accuracy (0/1) and response-time (0.75-2.0), 12 incongruent tasks in **gold** (e.g., Malmberg et al 2025)

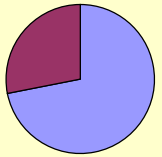
Time-series for multiple variables for multiple students (time on x-axis)



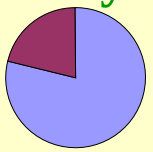
Competence belief



Effort exertion

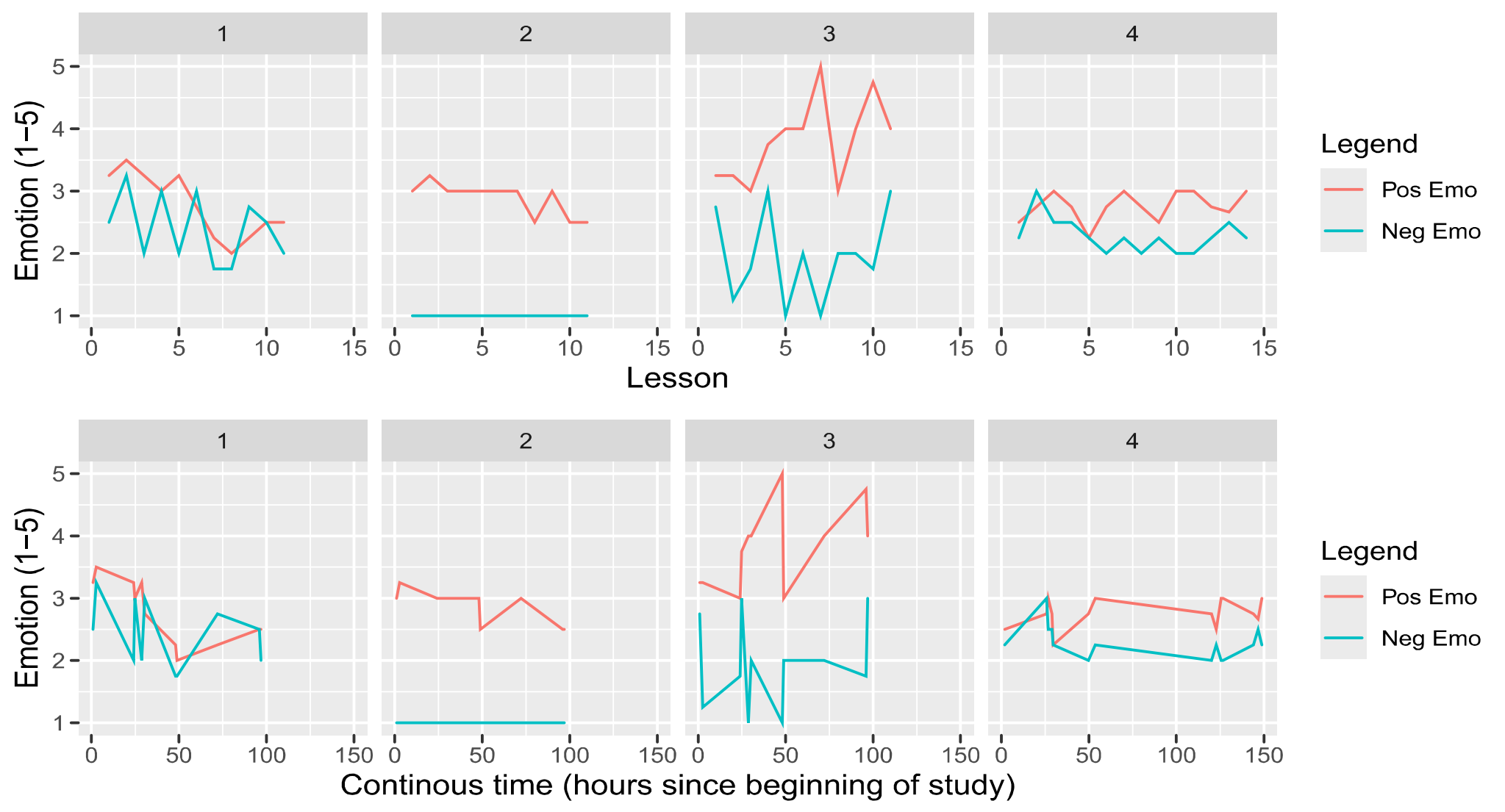


Task Difficulty



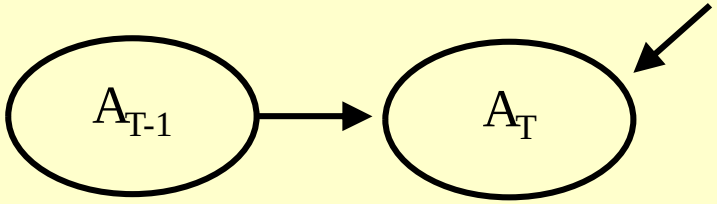
Variance %
= Within
= Between

Time-series for multiple variables for multiple students (time on x-axis)

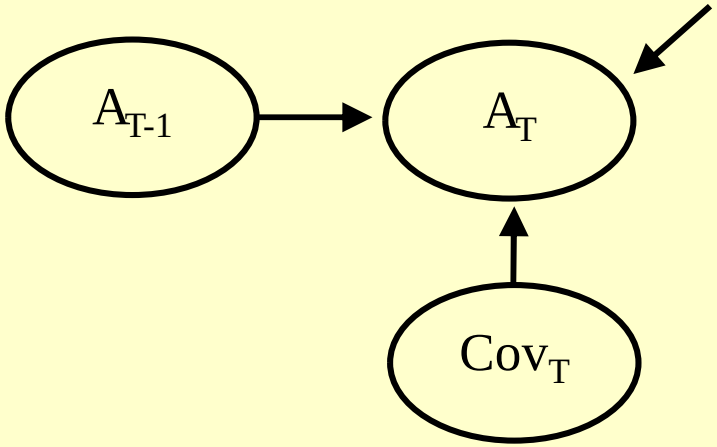


Process models

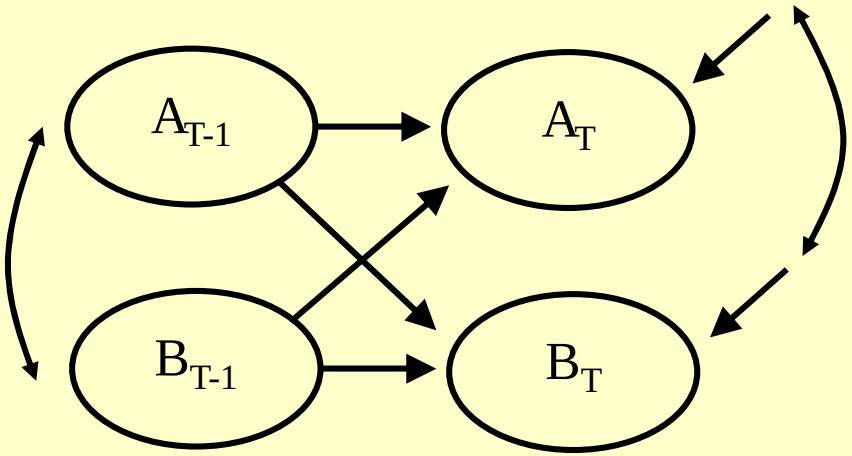
How stable is A across time?

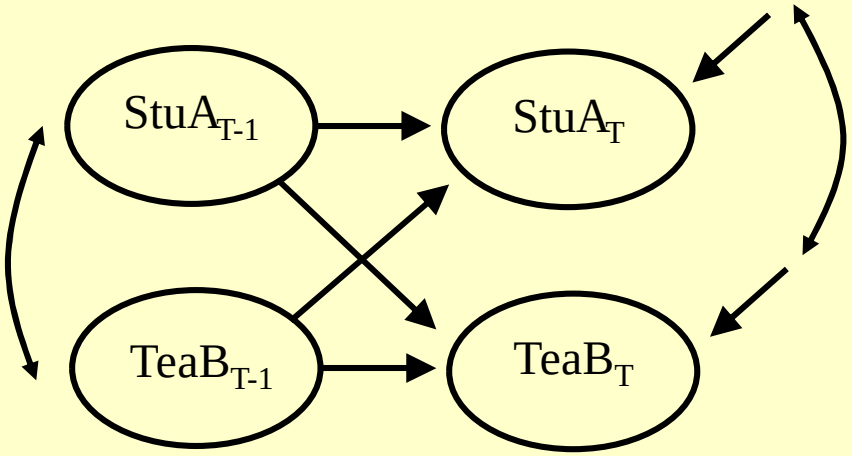


What is the effect of the time-varying covariate?



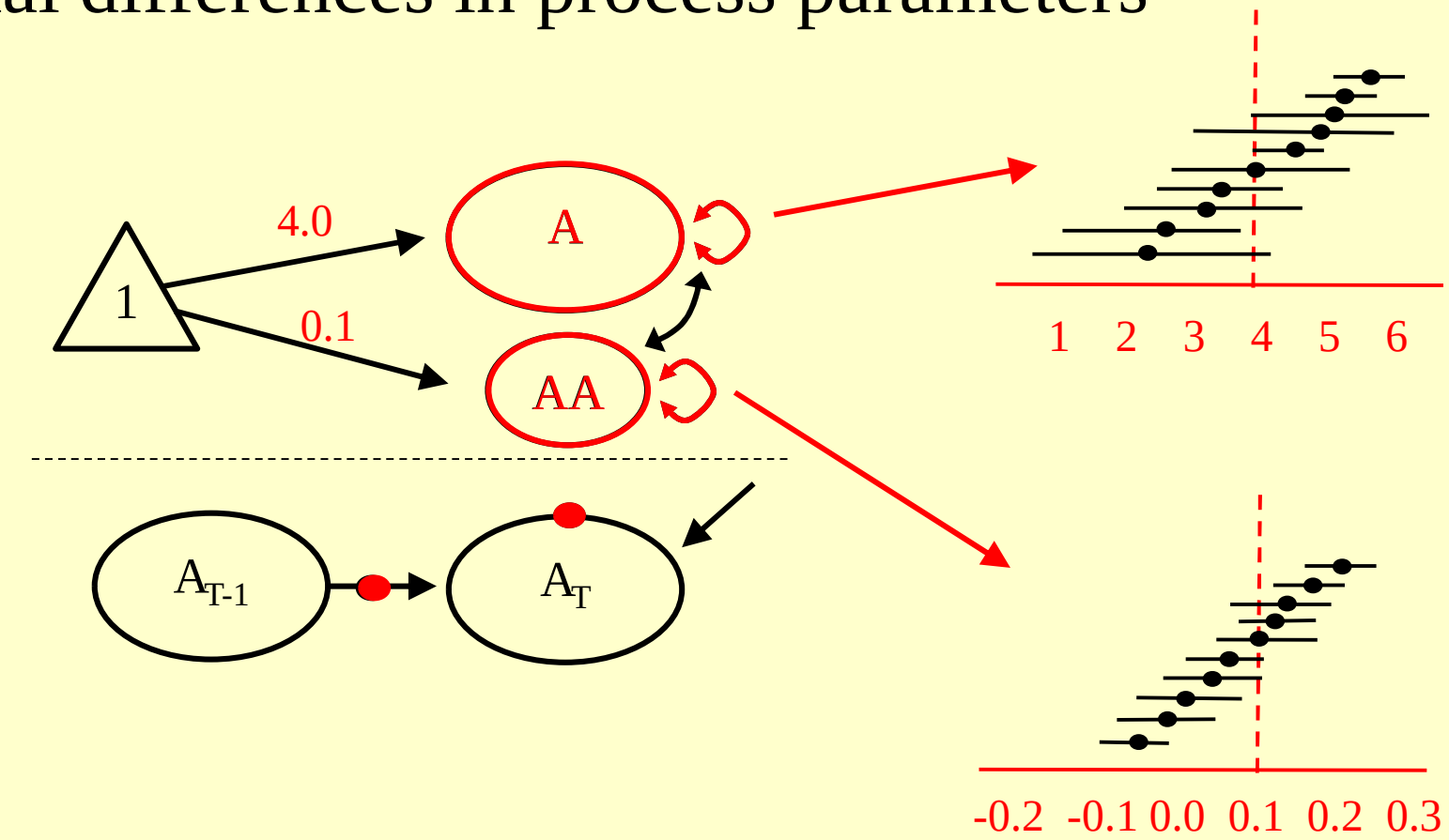
How do experiences predict each other over time?





A and B can also be different reporters, or self-report and objective measure

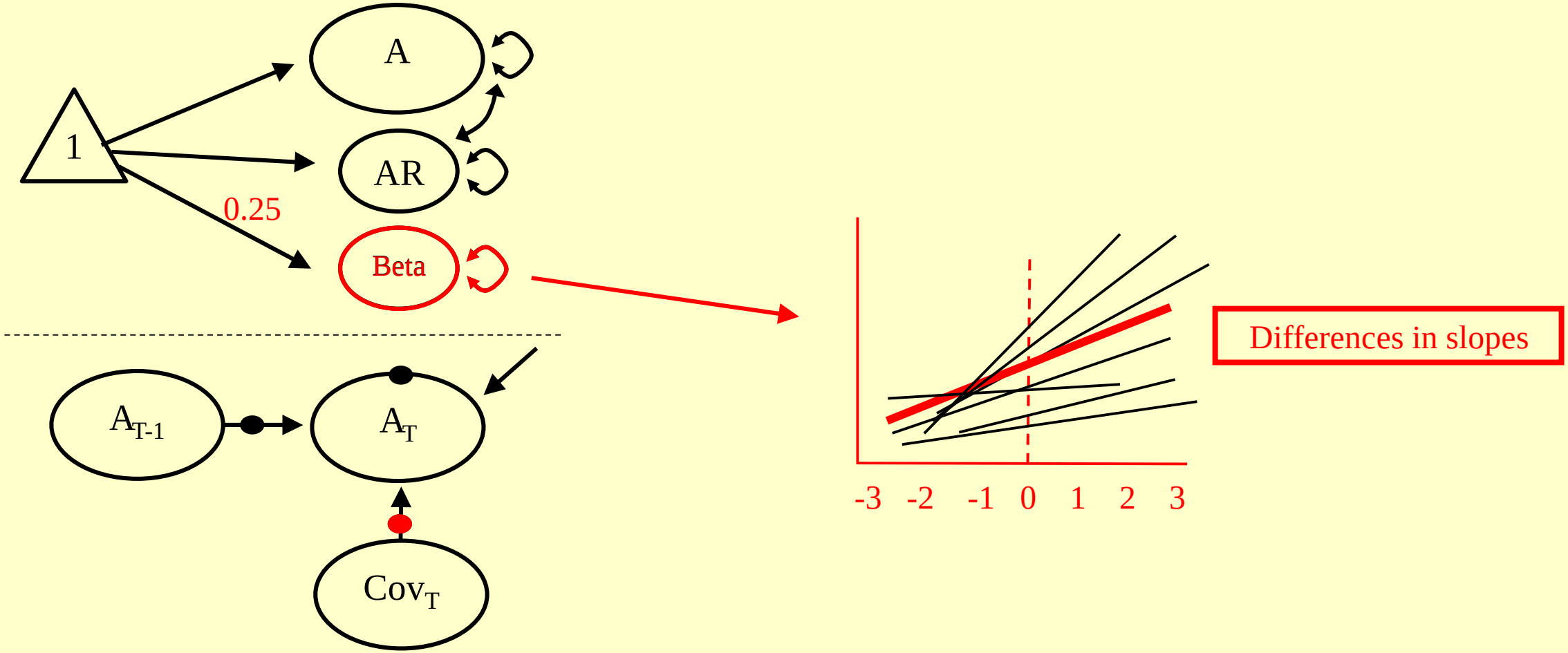
Individual differences in process parameters



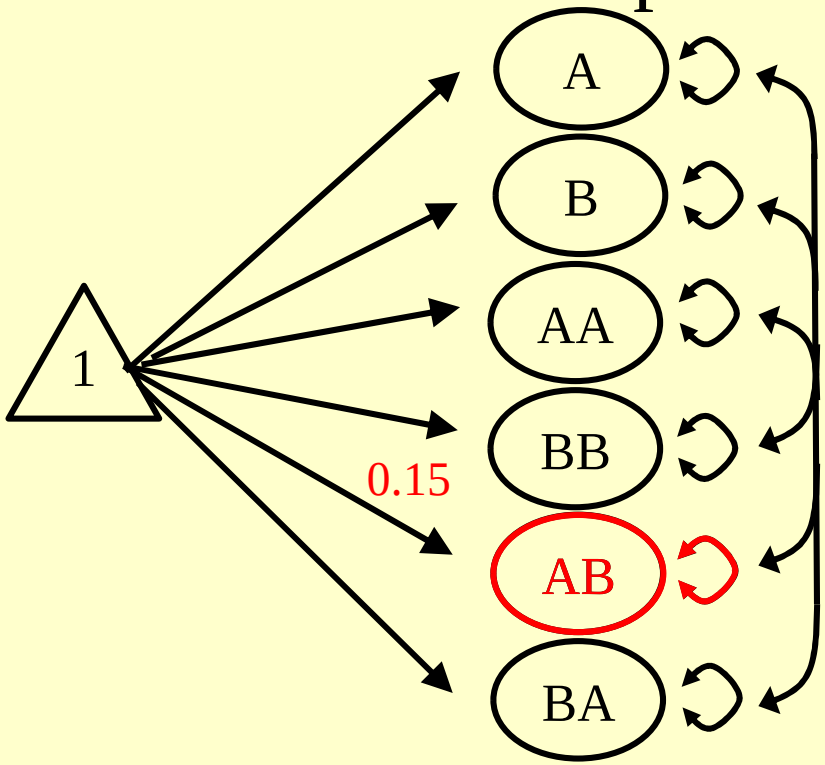
Differences in person-means (“traits”)

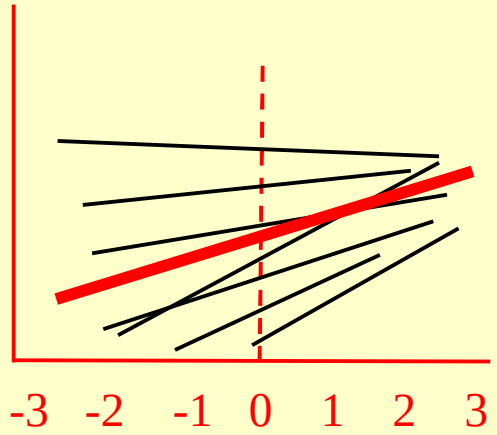
Differences in stability

Individual differences in process parameters

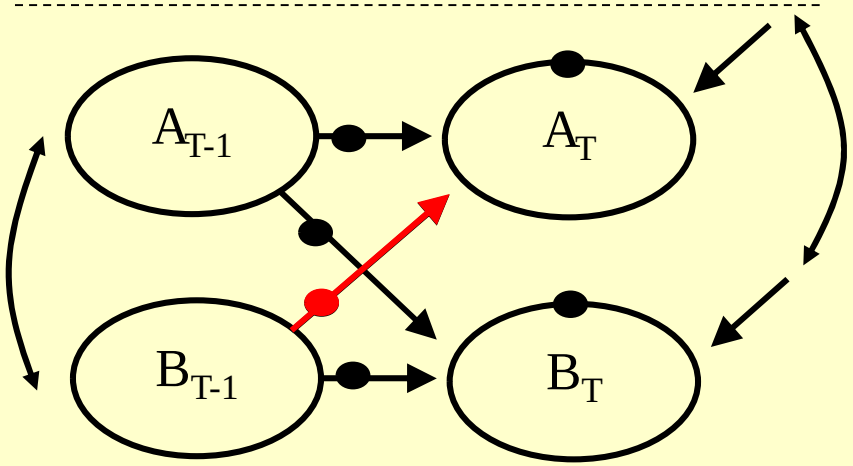


Individual differences in process parameters



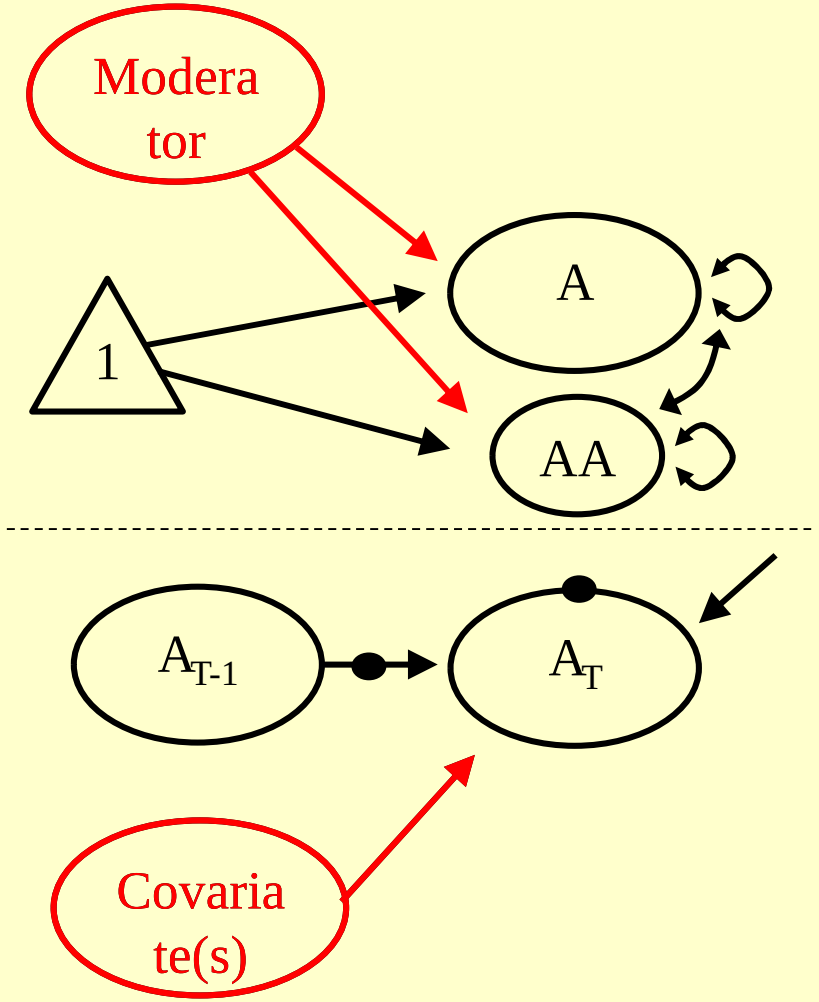


Differences in slopes

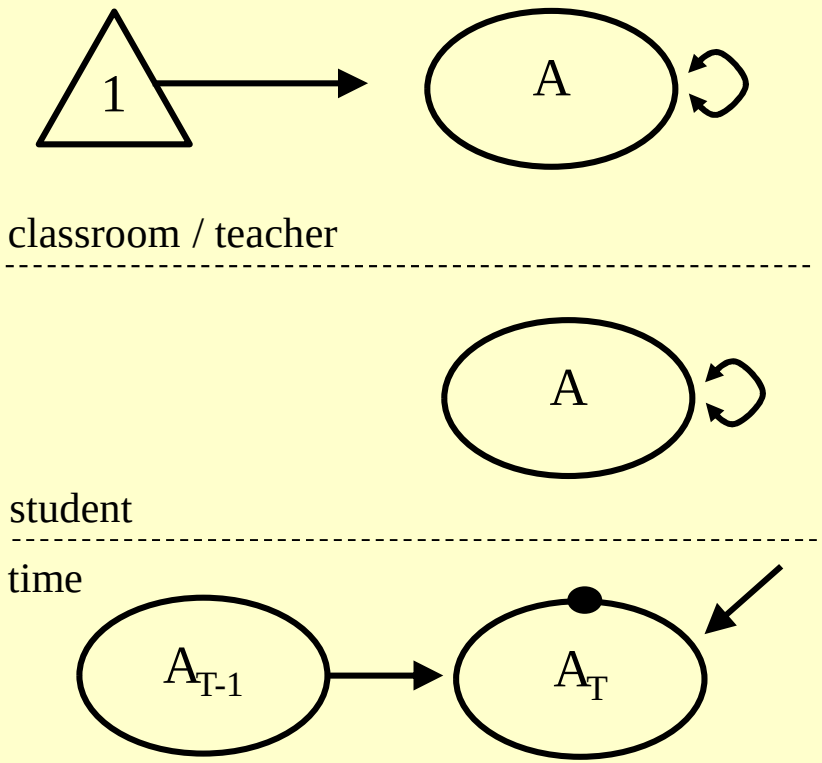


(Hamaker et al., 2018)

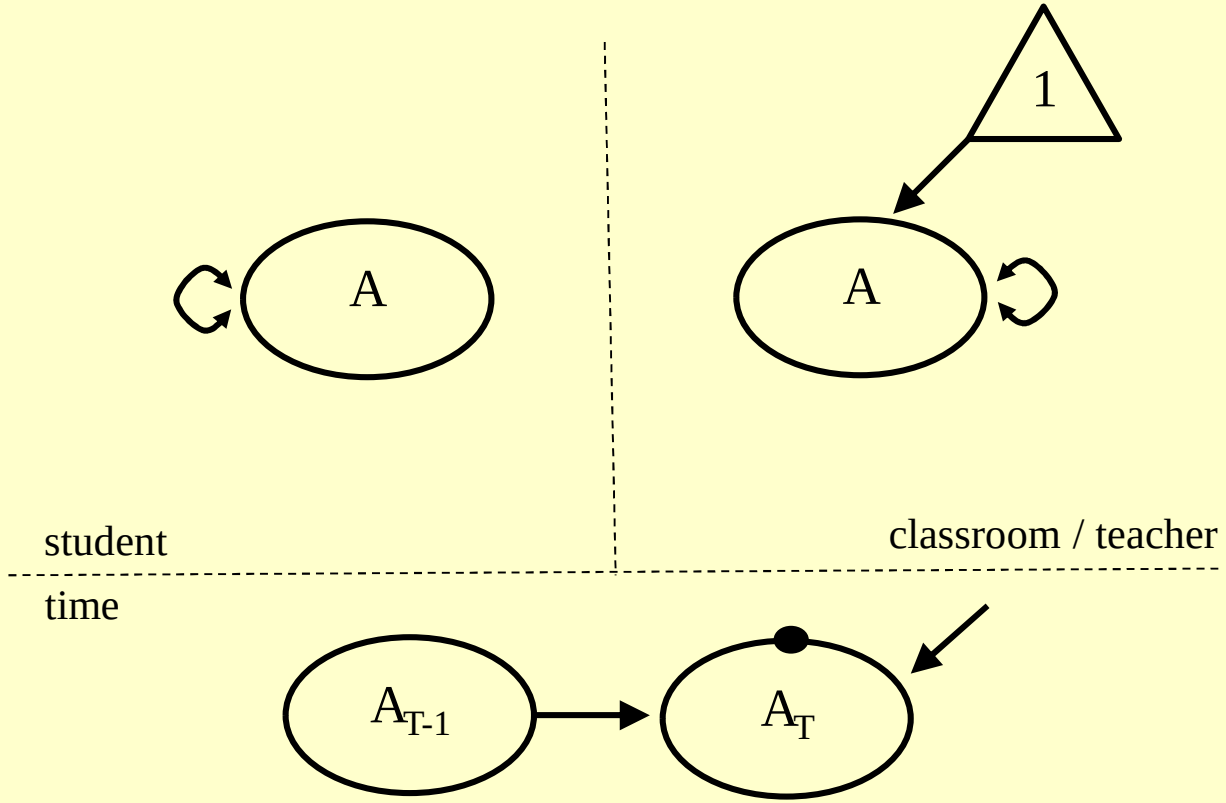
Then we include covariates, predictors and moderators



Three-level model



Cross-classified model



Critique against, and solutions for intraindividual research

Self-report bias → multiple reporters

Self-report bias → objective measures (e.g., task-performance, biophysiological measures)

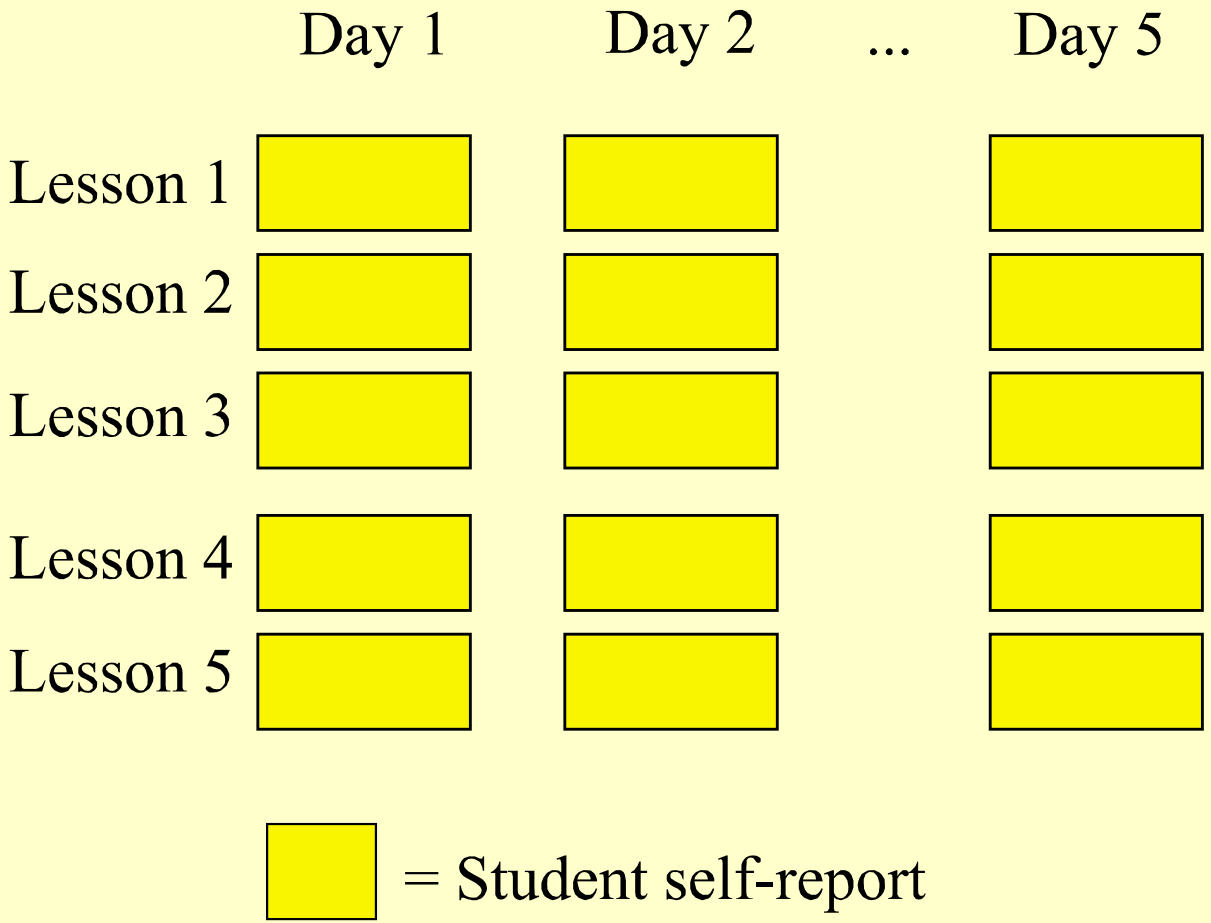
Correlational design → experimental designs (e.g., nudge-designs, e.g., Breitweiser et al 2021)

2. Multiple reporter studies

Student-reports	Teacher-reports
Project 1: (Learning Every Lesson)	
Learning experiences:	S's task-focus
competence belief, effort,	Involvement with S
task difficulty, motivation	S's academic performance
Project 2: Pei-Hsin Li	
S's emotions	T's emotions (situations)
S's perceptions of T's emotions	Student-teacher relationship (trait)
	Four target students' engagement (situations)
Project 3: Karin Street	
S's self-efficacy & mastery experiences	Observed quality of student-teacher interaction

323 primary school students in the UK took part: 4,972 lesson responses (M = 15.4, 2-34), M_{age} = 10.5 (SD = .63), Median response time was 109 sec (1 min 49 sec; M = 139 sec, SD = 75 sec; range 3 -540), 117 students in Year 5 and 206 in Year 6, 147 boys and 176 girls.

Learning
Every
Lesson

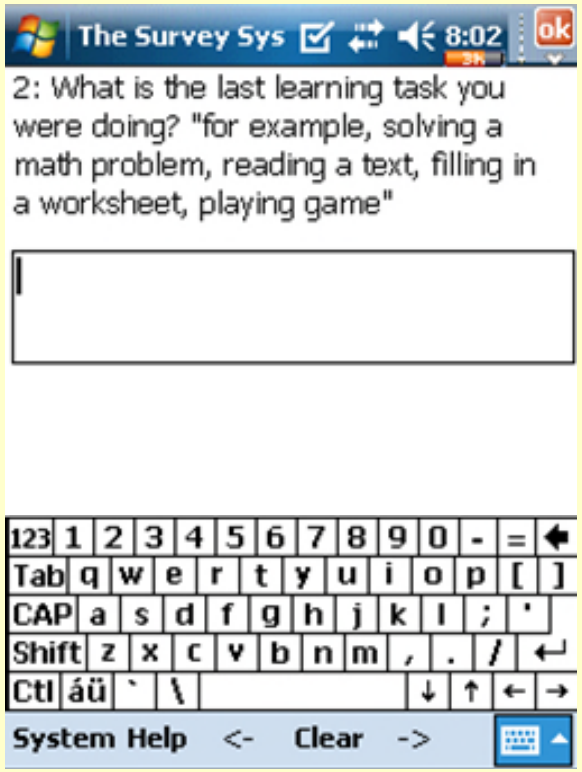


Learning Experience Questionnaire, LEQ
Teacher reports: performance, task-focus, involvement

PDA questionnaire

Learning Every Lesson

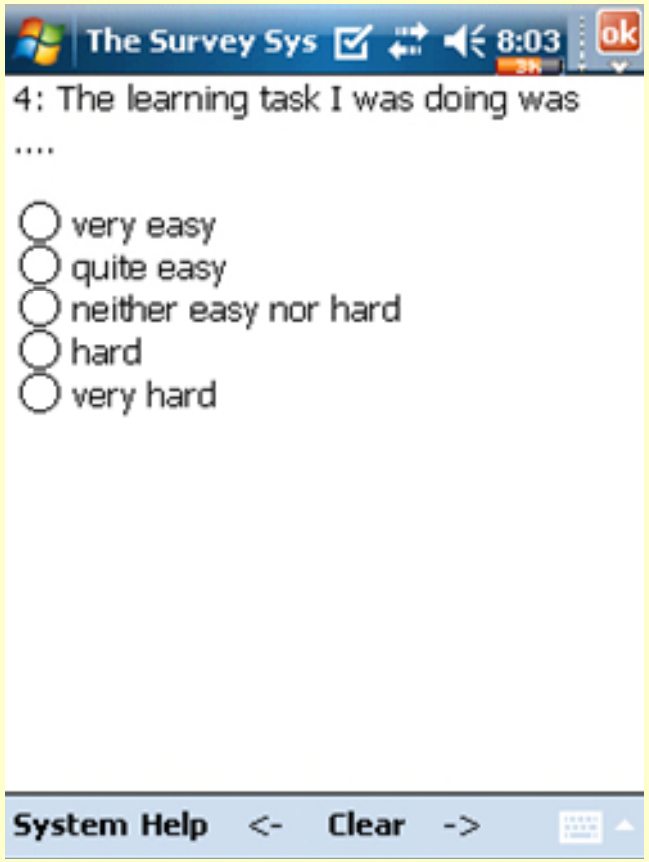
* Students instructed to use PDA during 1-hour start-up session
* Asked to complete once per learning episode (event-triggered), but at least once per lesson (fixed response)

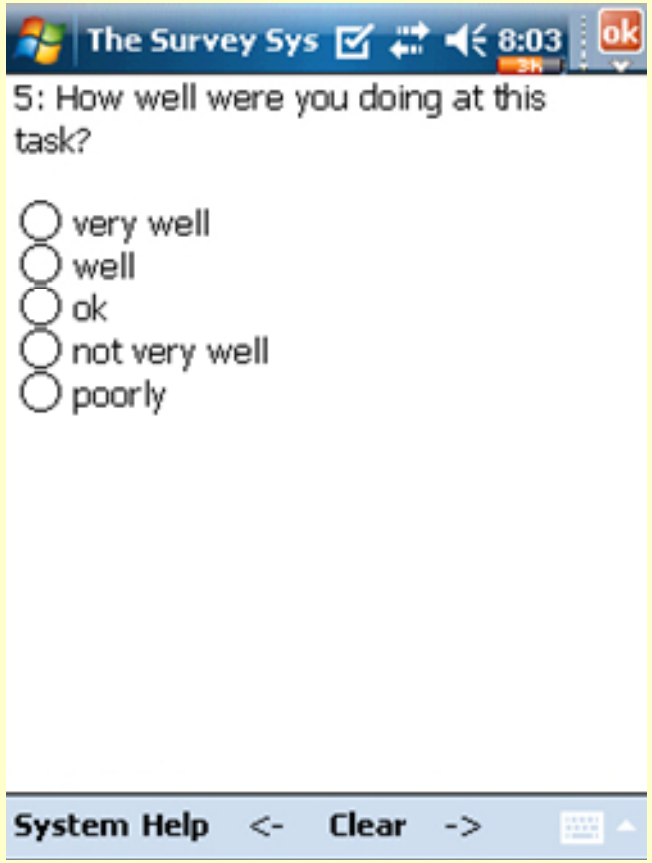


PDA questionnaire …. (2)

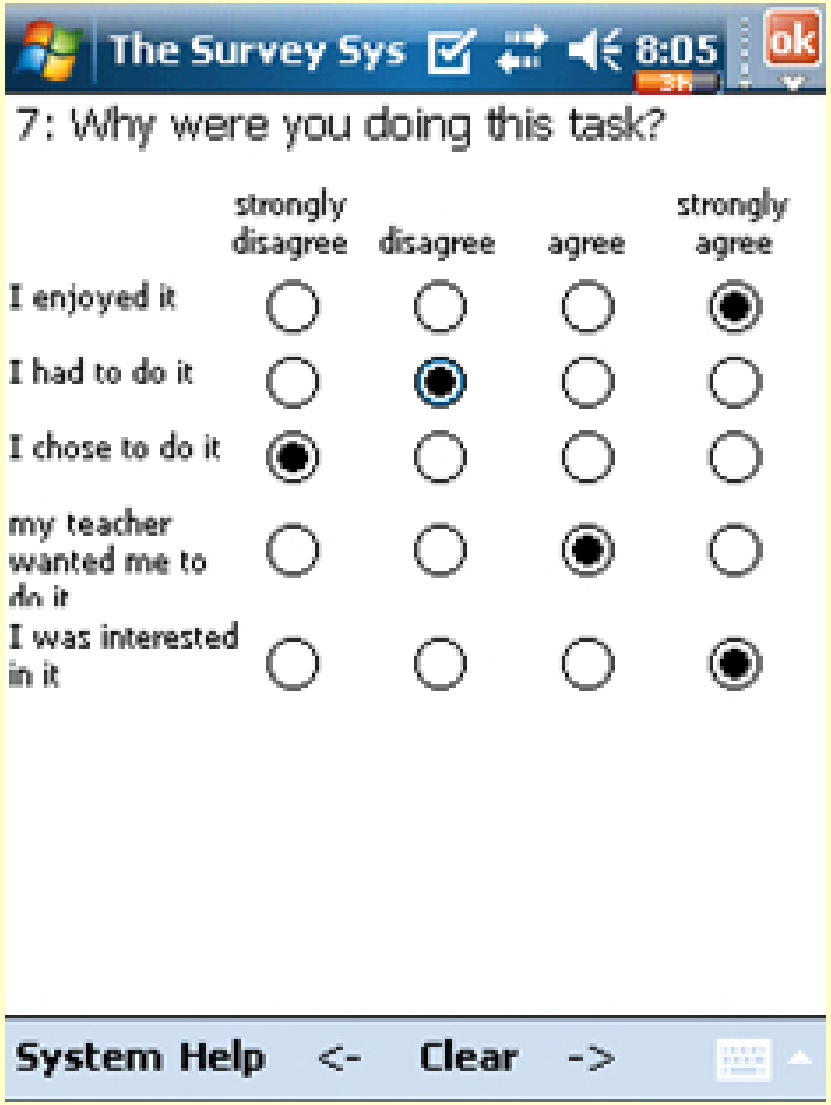
* Situation-specific difficulty and competence belief

Learning Every Lesson





PDA questionnaire: motivation

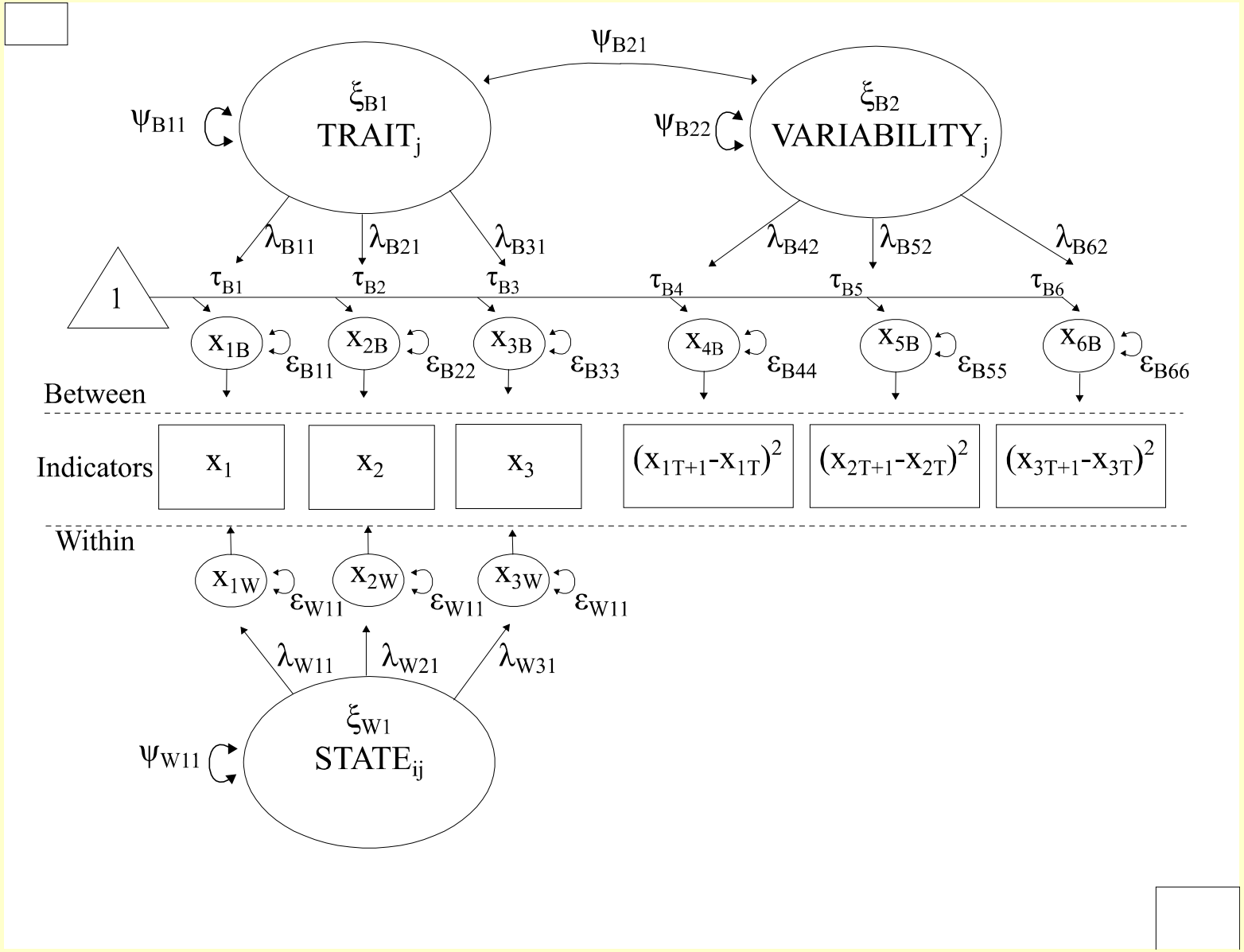


* A priori factor structure:
* Autonomous (intrinsic) motivation = ‘enjoyed it’, ‘chose to do it’ and ‘interested’
* Controlled (extrinsic) motivation = ‘had to do it’ and ‘teacher wanted me to do it’

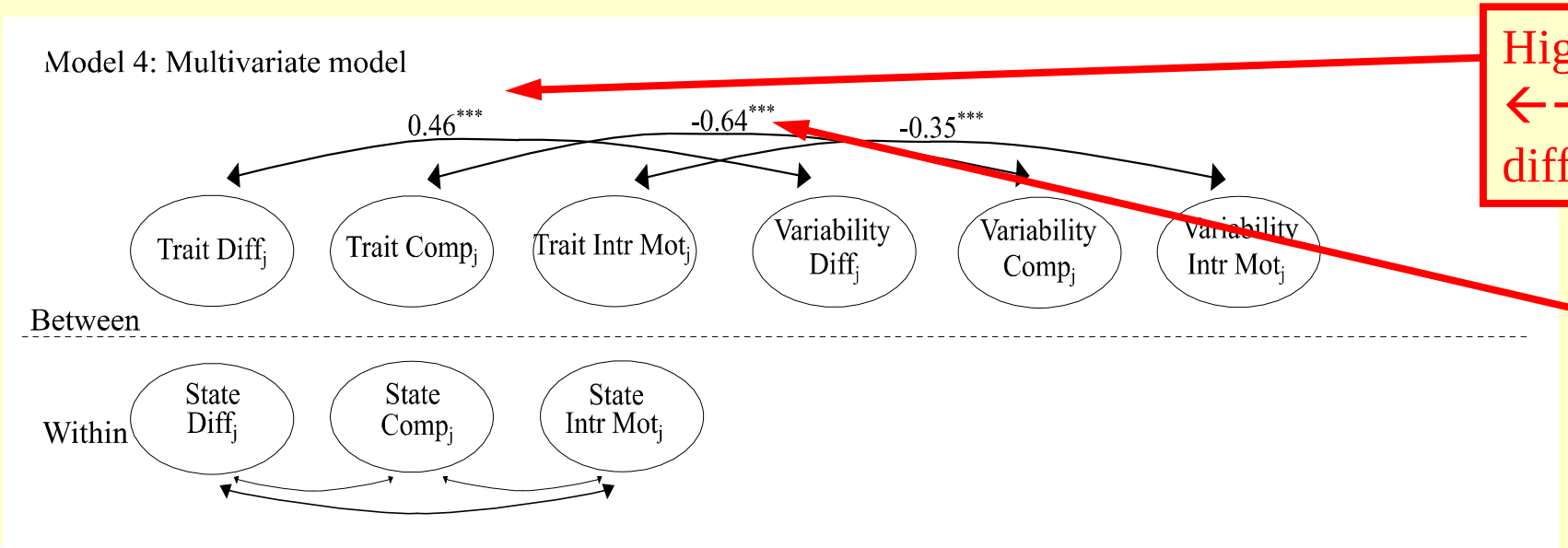
2.1 Intraindividual variability of students' learning experiences and teacher-reported task-focus

Malmberg, L-E., Lim, W. H. T., Tolvanen, A., & Nurmi, J-E. (2016). Within-student variability in learning experiences, and teachers' perceptions of students' task-focus. *Frontline Learning Research,4*, 62-82. doi:10.14786/flr.v4i5.227

Multilevel structural equation model of latent state, trait and intraindividual variability

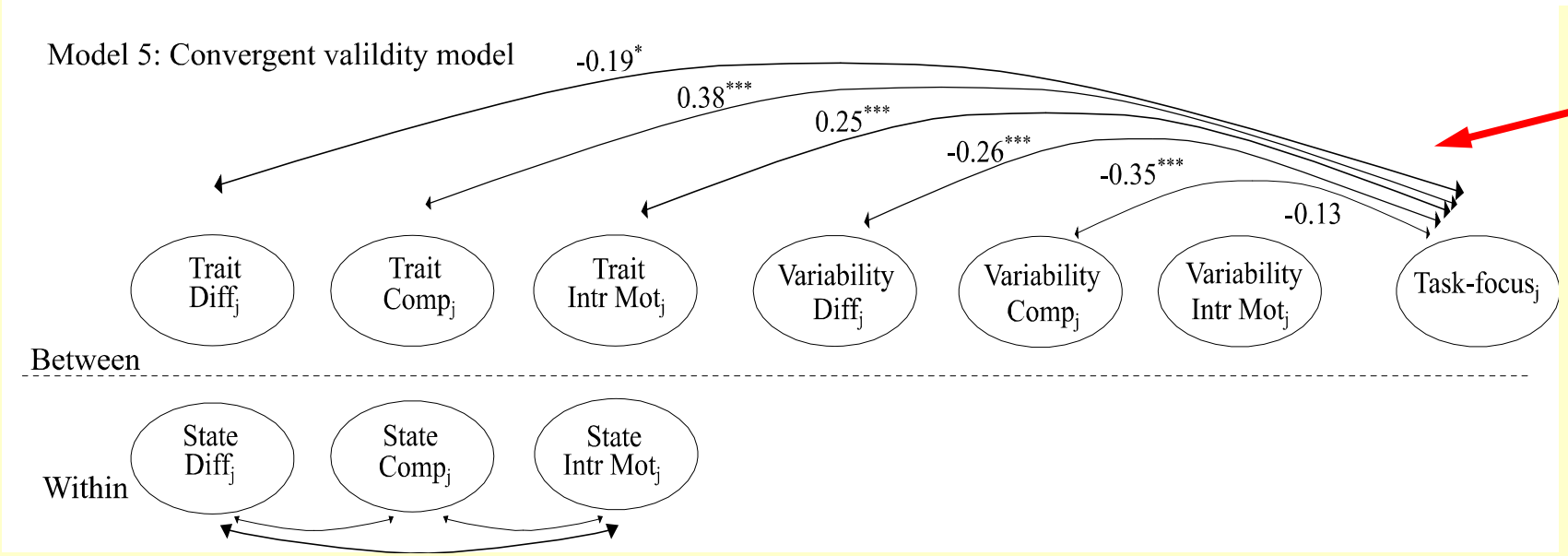


State, trait and instability of difficulty, competence and intrinsic motivation



Higher trait difficulty was ←→ more instability in difficulty

Higher trait competence ←→ with less instability



Task-focused students were less variable from one time-point to the next

(1) All students have their ups and downs

(2) Individual differences in instability captured by the MSSD

(3) Teacher rated engagement (task-focus) predicted trait levels

(4) … and less instability

Design and modelling

→ Teacher reports of students “in general” tapping into teachers’ accumulated knowledge of students, rather than situational

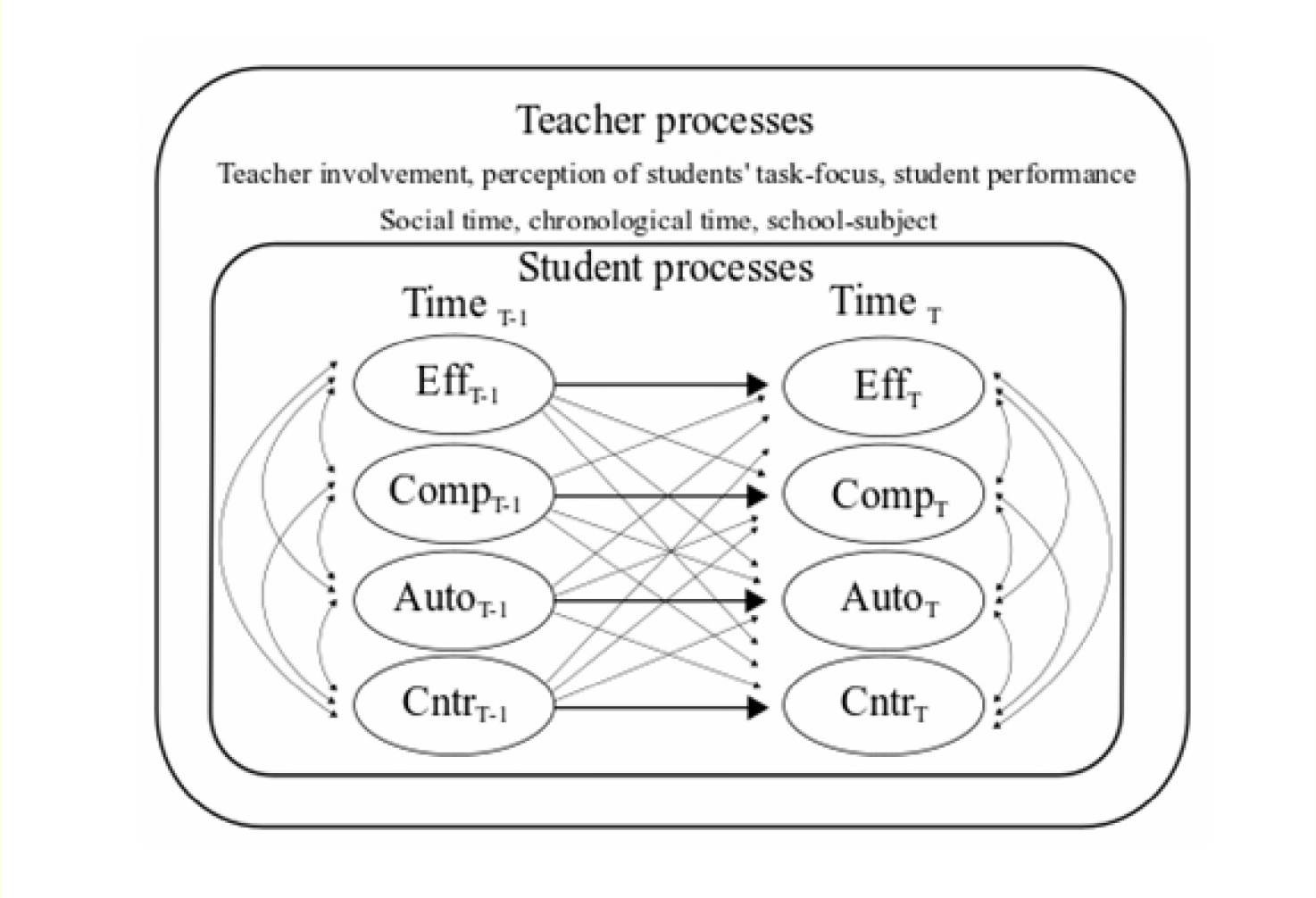
2.2 Learning experiences and teacher-reported involvement and task-focus

Malmberg, L-E., & Martin, A. J. (2019). Processes of students' effort exertion, competence beliefs and motivation: effects of lagged within-day and within-school-subject experiences. *Contemporary Educational Psychology, 58*, 299-306. doi 10.1016/j.cedpsych.2019.03.013.

We adapted the seminal model by Schmitz & Skinner (1993)

* Multilevel framework

* Novel lagged variables: within days, within subjects



Learning
Every
Lesson

Teacher-reports of

T's own involvement with each student

Six items characterizing the student-teacher relationship (0=not at all, 4=very often):

e.g., "I spend one-to-one time with him/her"

Each students' task-focus

Six items (three positively and three negatively worded items) on 5-point scales (0=not at all, 4=very often), modified from Zhang et al., 2011.

e.g., "actively attempts to solve even difficult tasks", "gives up easily"

Academic performance

Following English curriculum levels

Whom do teachers' get involved with?

Learning
Every
Lesson

Table: Between-level (students) correlation matrix

	$Effort_i$	$Comp_i$	$Auto_i$	$Cntr_i$	Perf	Focus	Inv
$Effort_i$							
$Comp_i$	.23						
$Auto_i$	.29	.50					
$Cntr_i$	.20	.30	.44				
Perf	*.07*	.49	*.08*	.24			
Focus	.14	.41	.21	.21	.71		
Inv	*-.21*	-.28	*-.03*	*.01*	-.45	-.42	

Teachers were more involved with students who on average exerted less effort and felt less confident during the week.
Teachers were more involved with less focussed and lower performing students

Teacher reports on each student combined with students' process-data (here averages over one week)

→ Here: Associations estimated at the between-level (students) of the study

→ How do we model differences between teachers?

Design and modelling

Include both teacher and student situation-specific data into the same study

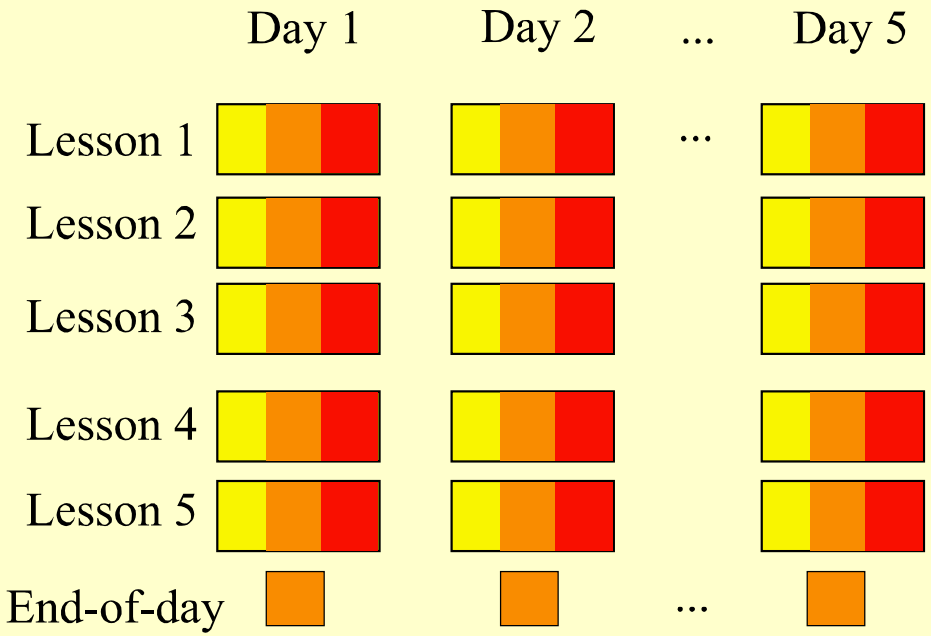
2.3 Students’ emotion and engagement and teachers’ emotions and involvement, in primary schools in Taiwan

Li, P.-H., Mayer, D., & Malmberg, L.-E. (2022). Teacher well-being in the classroom: A micro-longitudinal study. *Teaching and Teacher Education, 115*, 103720, doi: 10.1016/j.tate.2022.103720

Li, P.-H., Mayer, D., & Malmberg, L.-E. (2025). Are teachers' and students' emotions reciprocally transmitted in the classroom? *British Journal of Educational Psychology,* doi = 10.1111/bjep.70006 (Special Issue R. Lazarides & M. Dresel, Eds)

Li, P.-H., Mayer, D., & Malmberg, L.-E. (2024). Student engagement and teacher emotions in student-teacher dyads: The role of teacher involvement. *Learning and Instruction, 91*, 101876, doi = 10.1016/j.learninstruc.2024.101876

In total, 20 homeroom teachers in Taiwan and their 308 students from Years 4-5 took part.



Situational measures

= Ss' self-report, reports of T's emotions

= T's self-report, end-of-day report, and S-group's engagement

= T's reports of 4 target-Ss' engagement

Person measures

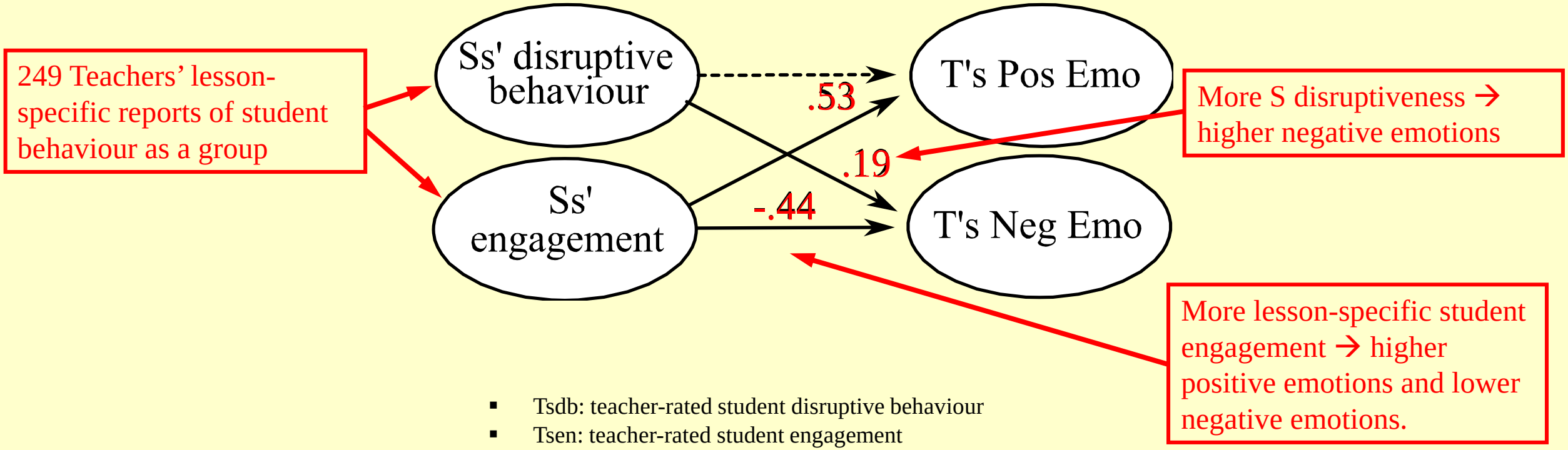
Ss' well-being (e.g., life-satisfatction): beginning and end of research

Ts' well-being (e.g, life-satisfaction): beginning and end of research

T-reported Ss' academic performance, closeness and conflict

Teachers' perceived student behaviour each lesson during one week

(within-level of 3-level SEM: lessons in days, in teachers)



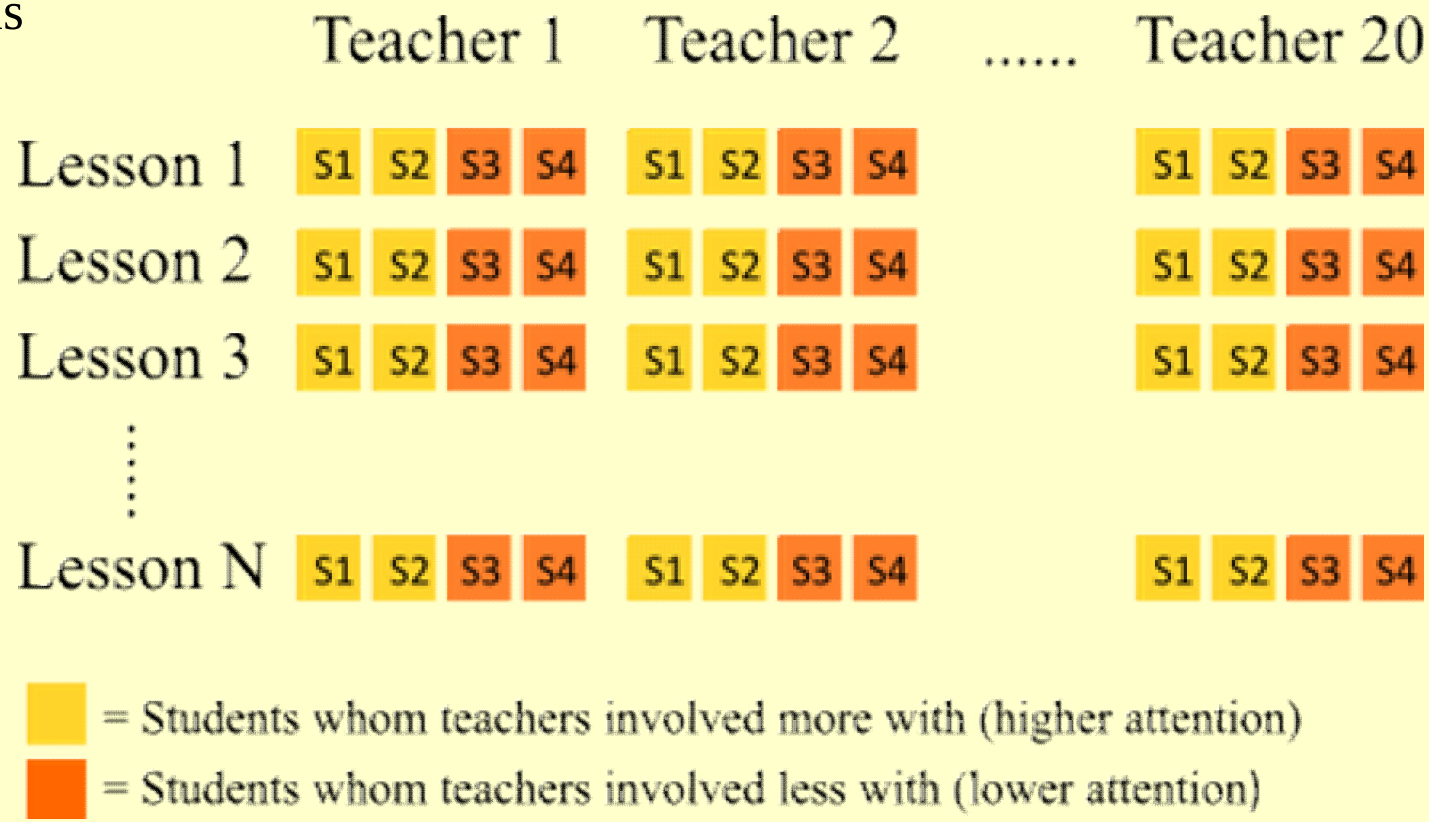
- Tsdb: teacher-rated student disruptive behaviour
- Tsen: teacher-rated student engagement

Novel design: four target students per teacher

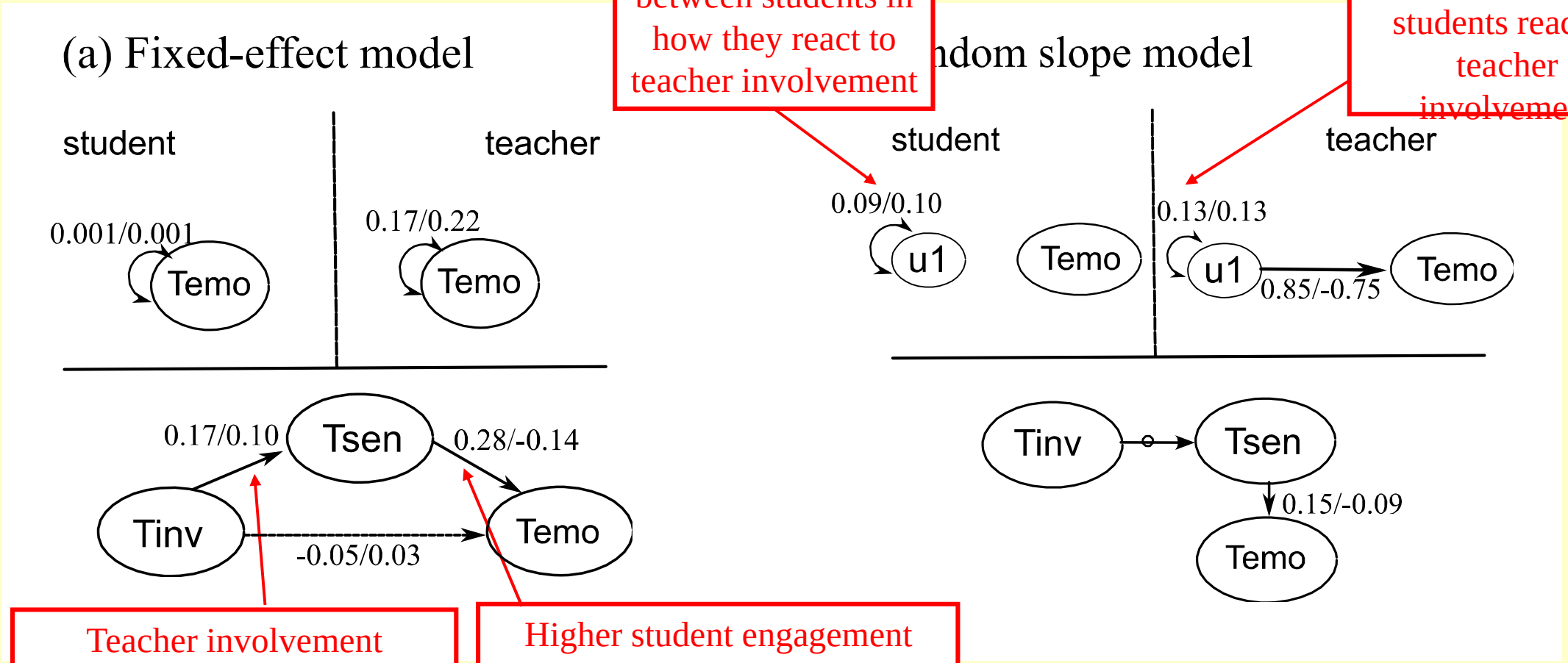
* 2 who they paid relatively more attention to in class (higher level of involvement) and 2 who they pay relatively less to attention (lower level of involvement).

* The teachers had both closer and more conflictual relationships with students in the high-involvement group

Teacher (n_i = 20) reports of individual students' (n_i = 80) situational engagement and their own emotions



Cross-classified SEM showed complex variation (time nested in both students and teachers)



Differences between students in how they react to teacher involvement

Differences in teachers in how students react to teacher involvement

Teacher involvement predicted higher student engagement

Higher student engagement predicted higher positive emotions and lower negative emotions in teachers

When students the teacher was more involved with were more engaged, this predicted teachers' emotions more strongly

When students the teacher was involved with were more engaged, this predicted teachers' emotions more strongly. Here: less negative emotions

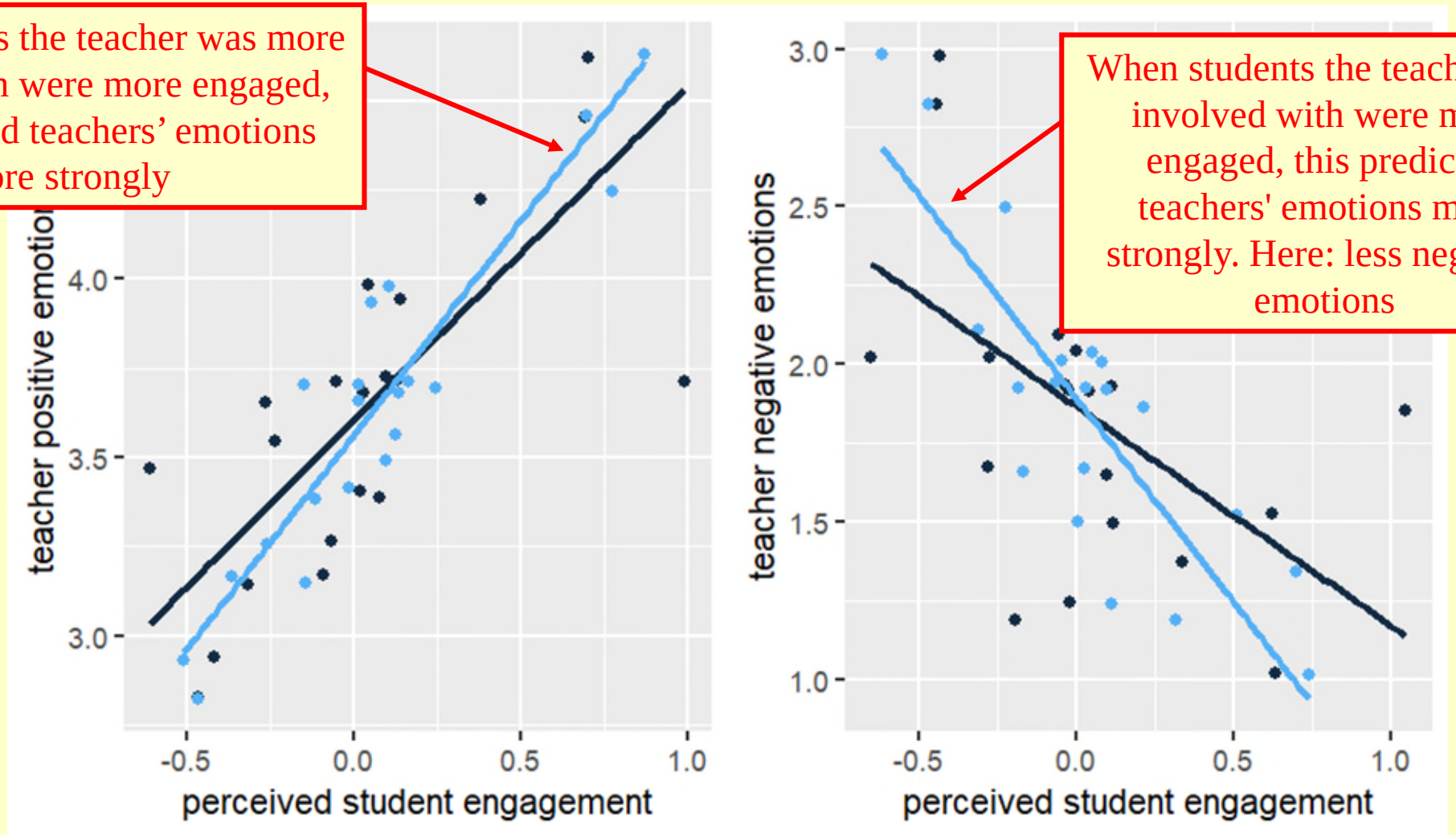
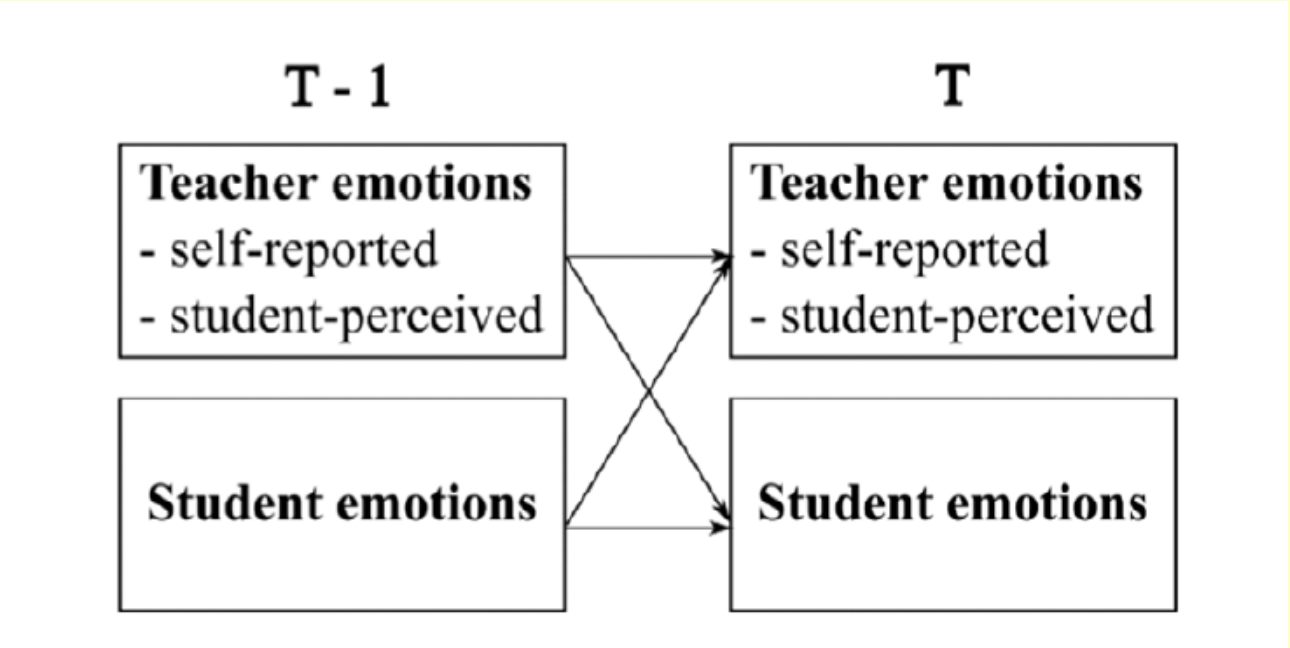


Fig. 3. Teacher emotions regressed on perceived student engagement for students the teacher is relatively less and more involved with
Note: **Blue lines** represent two target students the teacher was relatively **more involved** with, and **black lines** represent two target students the teacher was relatively **less involved** with.

Are teachers' and students' emotions reciprocally transmitted in the classroom? (Li, Mayer, & Malmberg, 2025)

* Emotions are “contagious” and can be transmitted from one person to the other, from one lesson to the next



* Teachers’ and students’ emotions in class were measured by eight positive and negative emotions: enjoyment (開心), relaxation (放鬆), pride (自豪), and calm (平靜), and negative emotions: disappointment (失望), anxiety (緊張), anger (生氣), and boredom (無聊).

Stability of emotions is weak

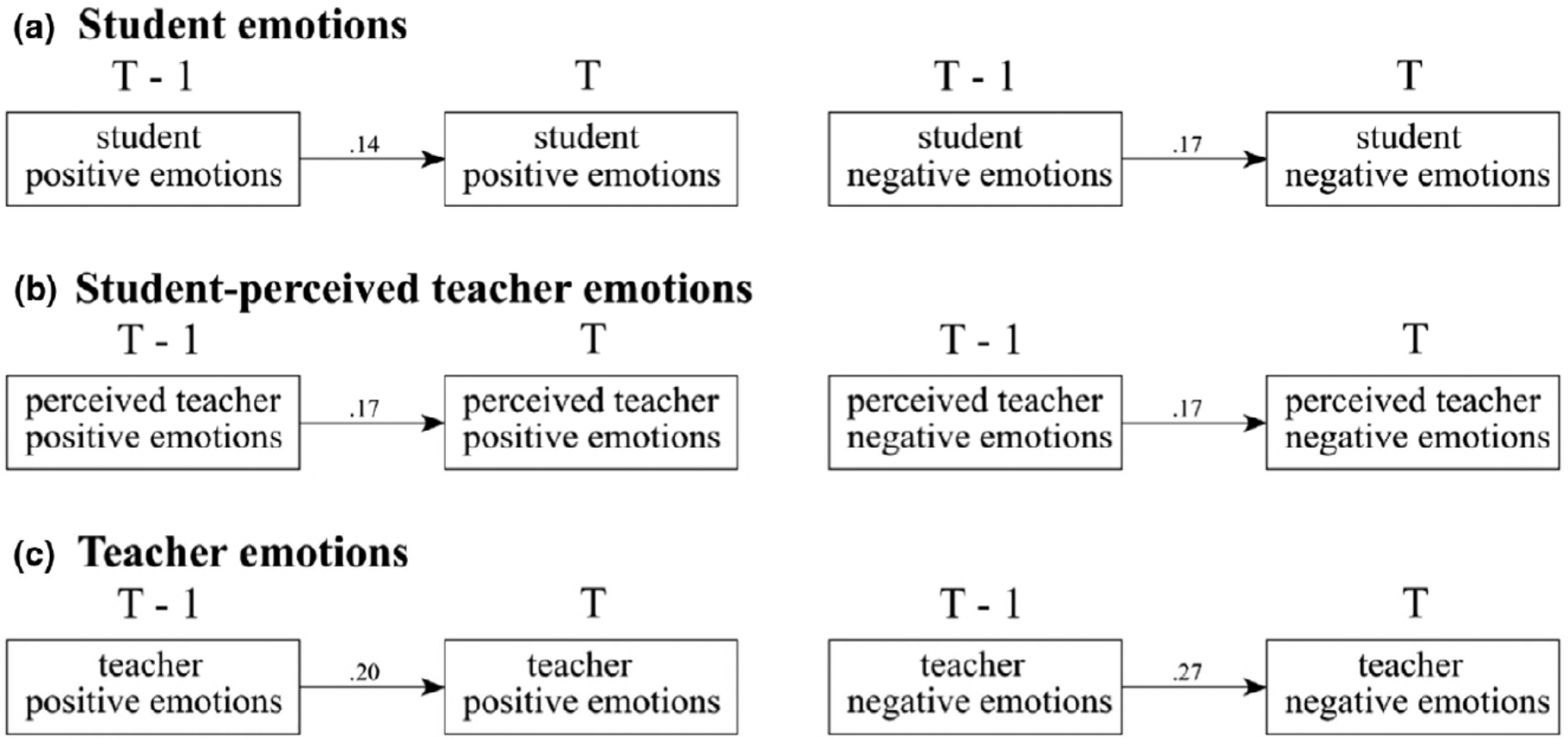
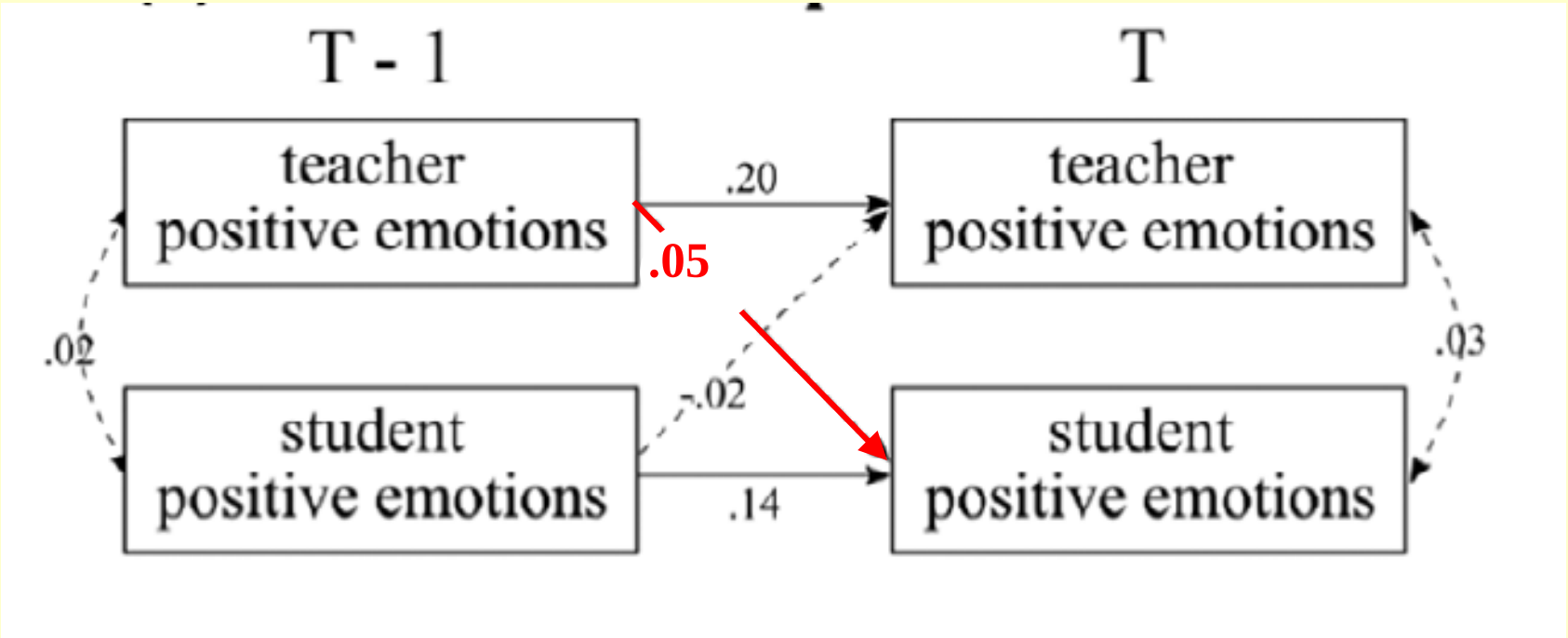


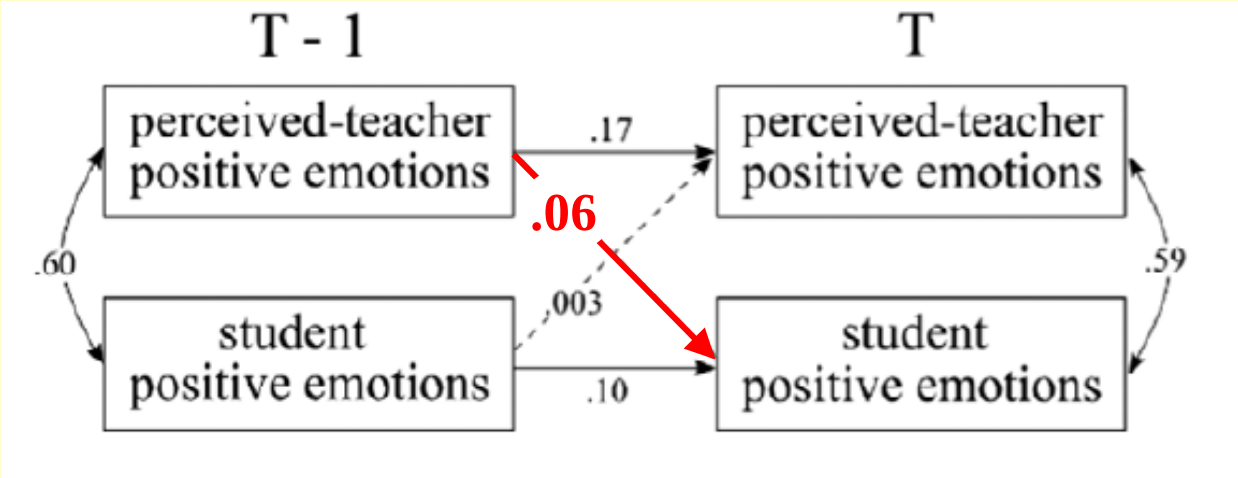
FIGURE 3 Teacher and student emotion stability. Standardized estimates were presented in the figure. The solid lines indicated credible intervals (CI) that do not include zero.

Teachers' positive emotions were transmitted to students' positive emotions. Negative emotions were not transmitted.

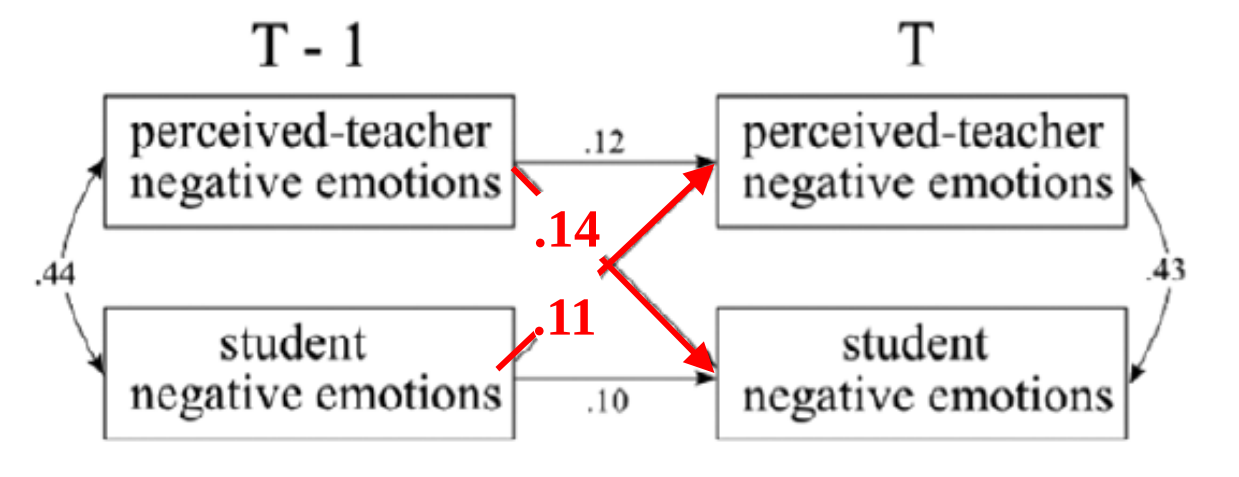


Do teachers supress negative emotions?

Students' perceptions of teachers' positive emotions were transmitted to students' positive emotions.



Reciprocal effects for negative emotions



Next steps

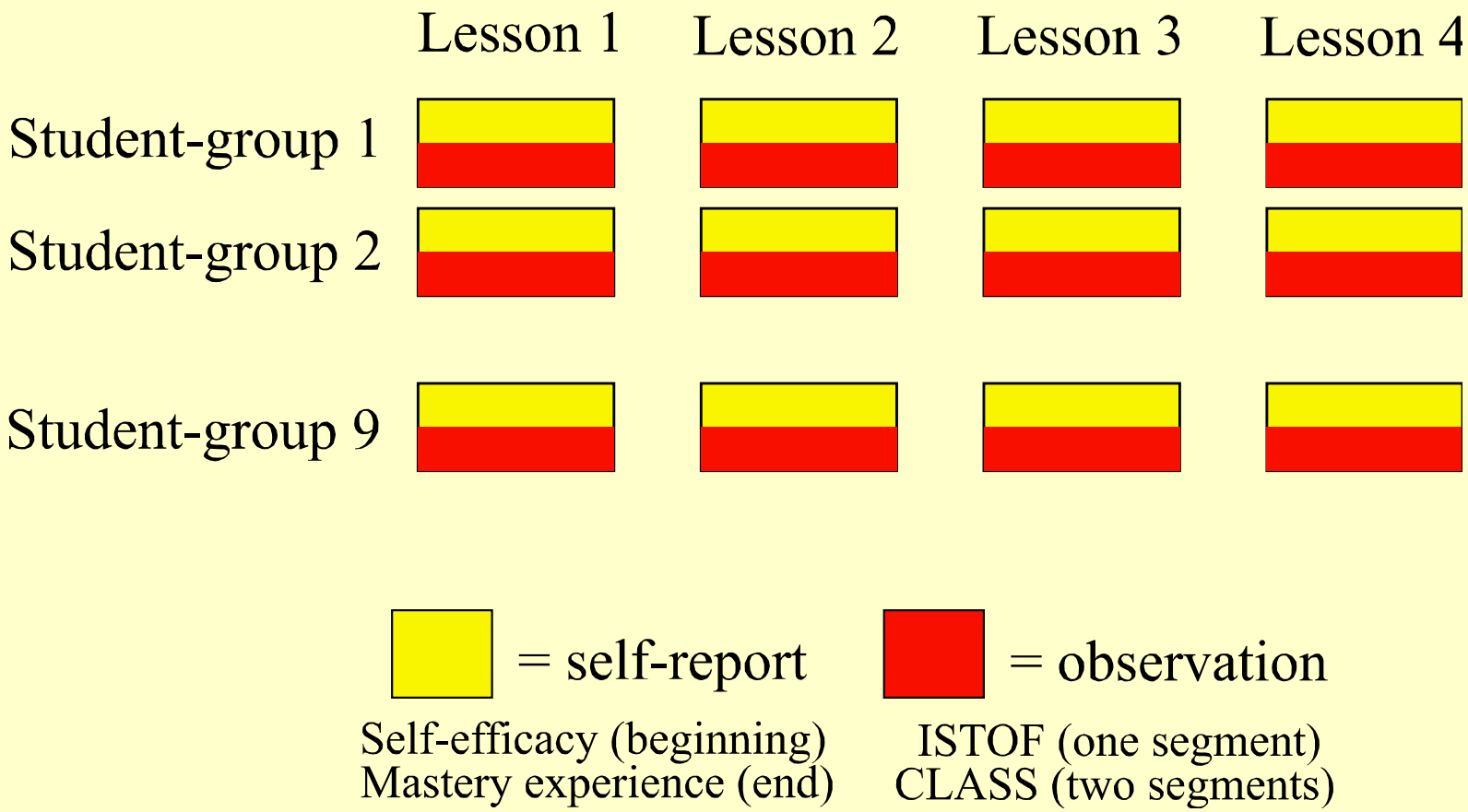
Link teachers' and students' reports of student engagement → do teacher and students agree with each other?

Can stronger agreement be explained by the student-teacher relationship (closeness, conflict)?

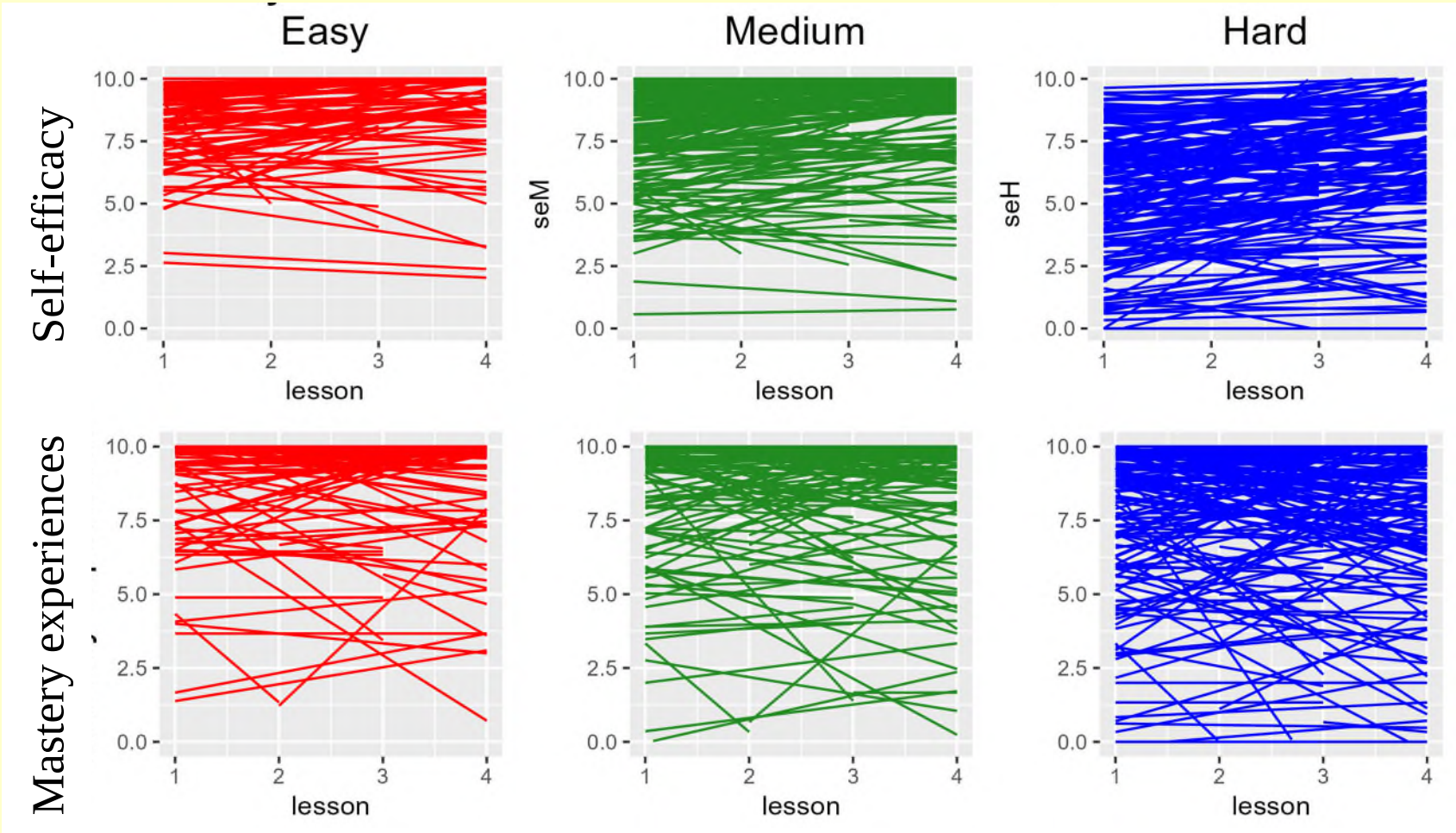
3. Students' self-efficacy and mastery experiences of mathematics and teachers' support

Street, K. E., Malmberg, L.-E., & Stylianides, G. J. (2022). Changes in students' self-efficacy when learning a new topic in mathematics: a micro-longitudinal study. *Educational Studies in Mathematics: An International Journal*. Open access: doi = 10.1007/s10649-022-10165-1

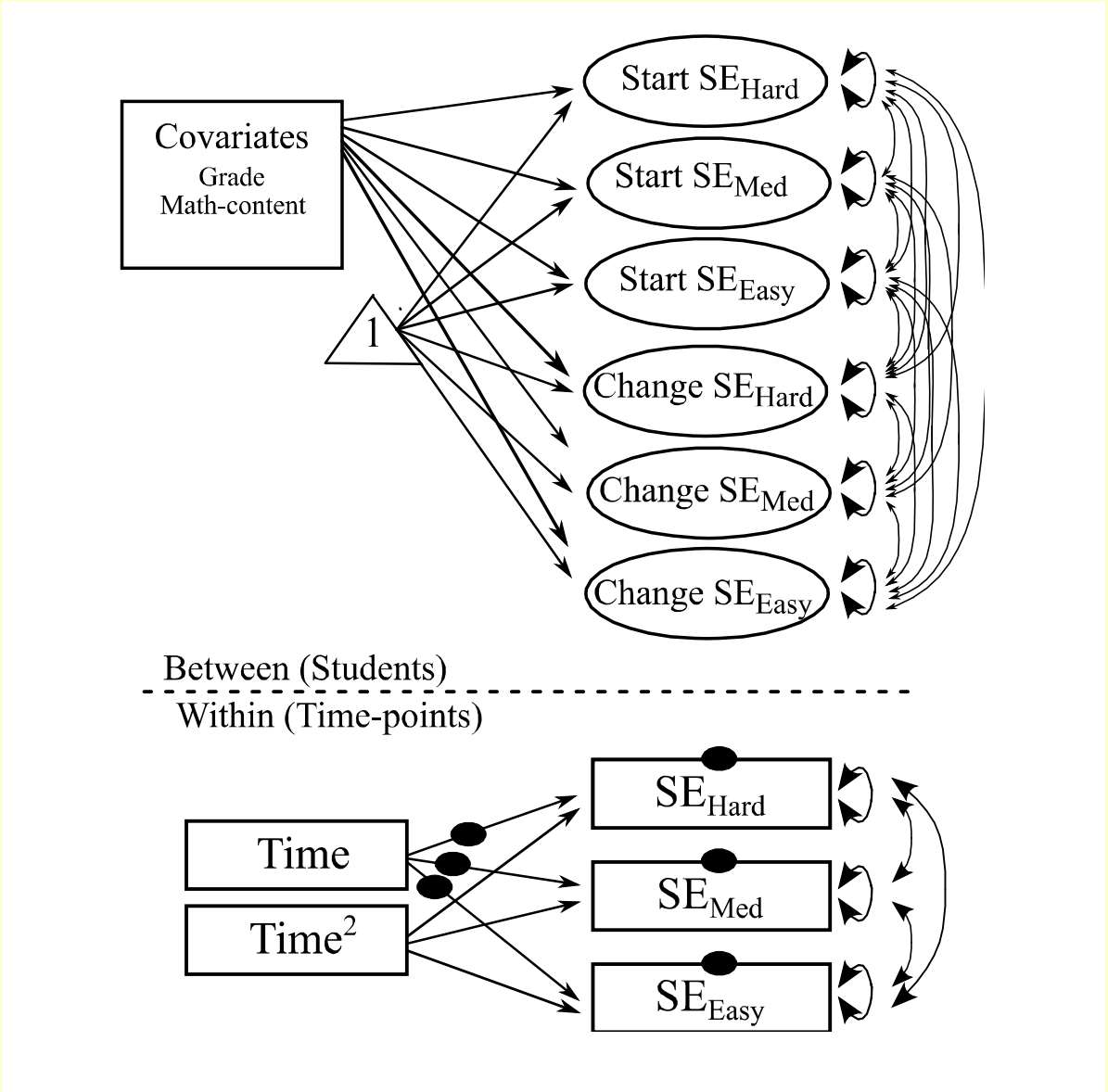
A micro-longitudinal study of students' self-efficacy and mastery experiences when learning a new topic in mathematics (n_i = 170, Grade 6 and 10 in Norway), n_{ti} = 596



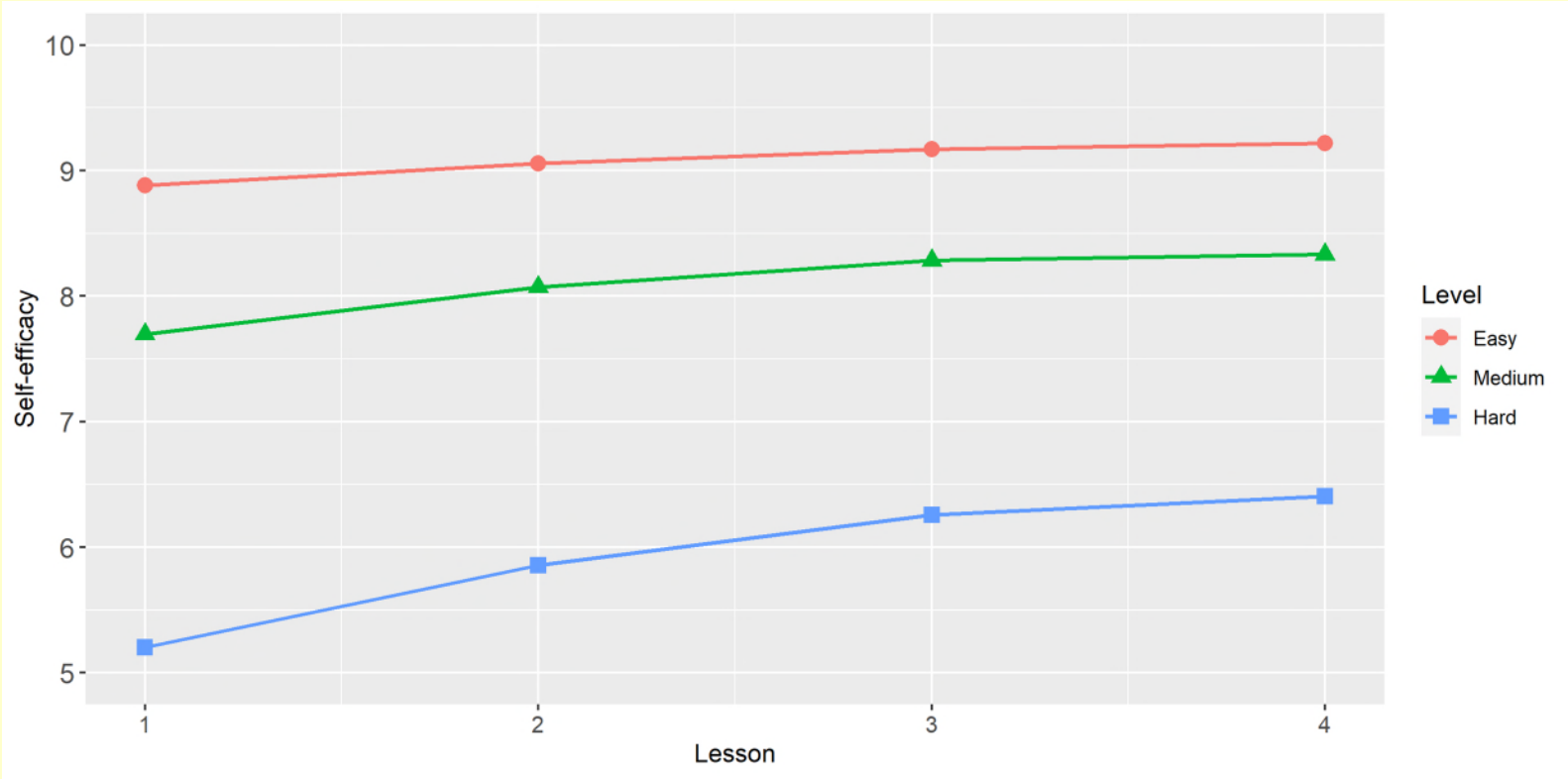
Predicted linear changes over time for self-efficacy (beginning of lessons) and mastery experiences (at the end of each lesson)



Bayesian multivariate multilevel model for change (Street et al 2022)



Students reported their self-efficacy ("confidence") for solving easy, medium and hard tasks, in four consecutive lessons.



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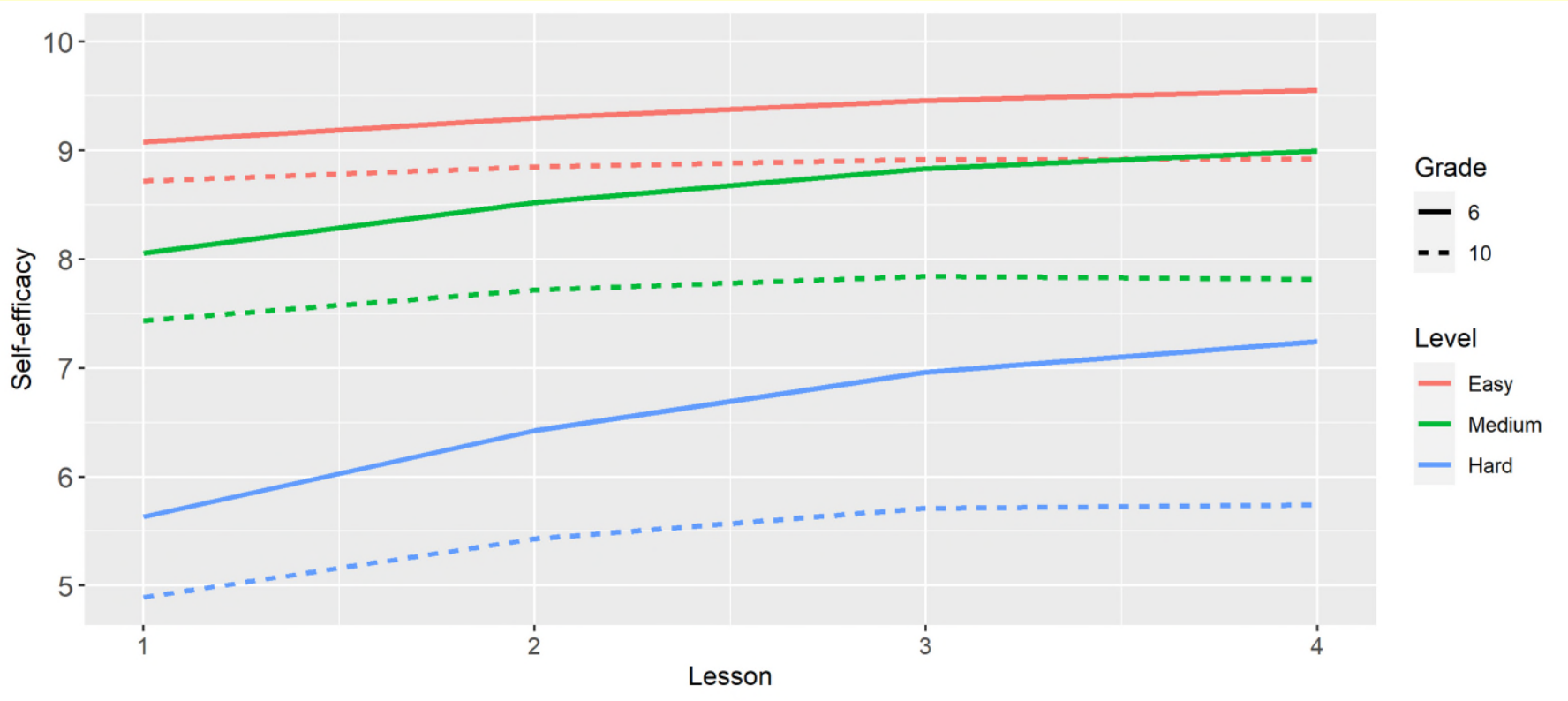
Self-efficacy of Year 6 students increased more than self-efficacy of Year 10 students.



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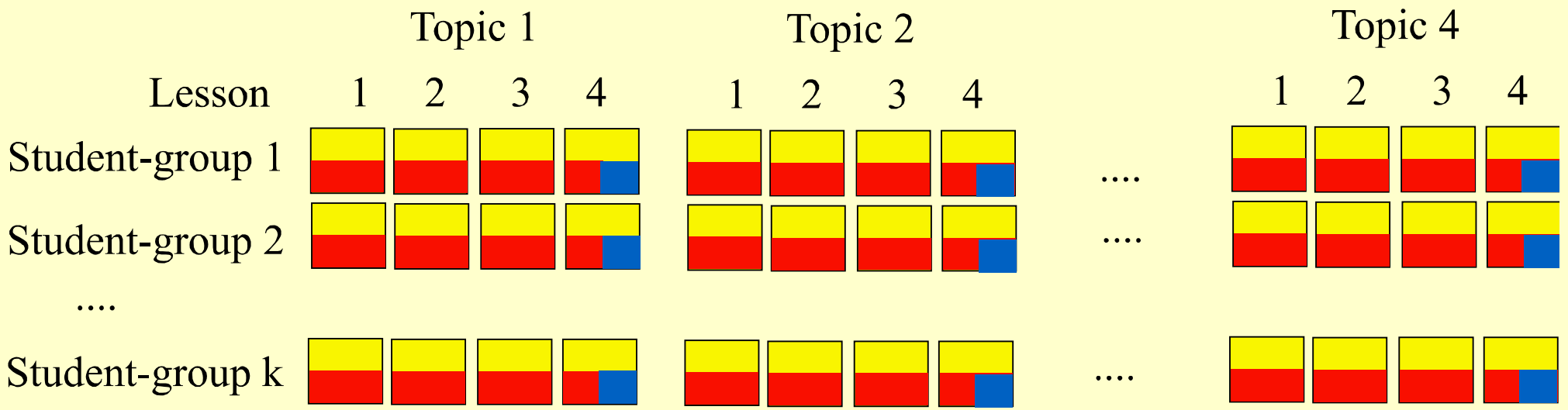
The SEMPER-study (Street et al 2023-27) includes situation-specific observed classroom quality (DYAD) and end-of-sequence math tasks



= self-report

Self-efficacy (beginning)
Mastery experience (end)

= observation

CLASS (two segments)
DYAD ( )

= math tasks

Stay tuned! ☺

4. Links with objective measures

Cognition (working memory, executive functions)
Vocabulary)

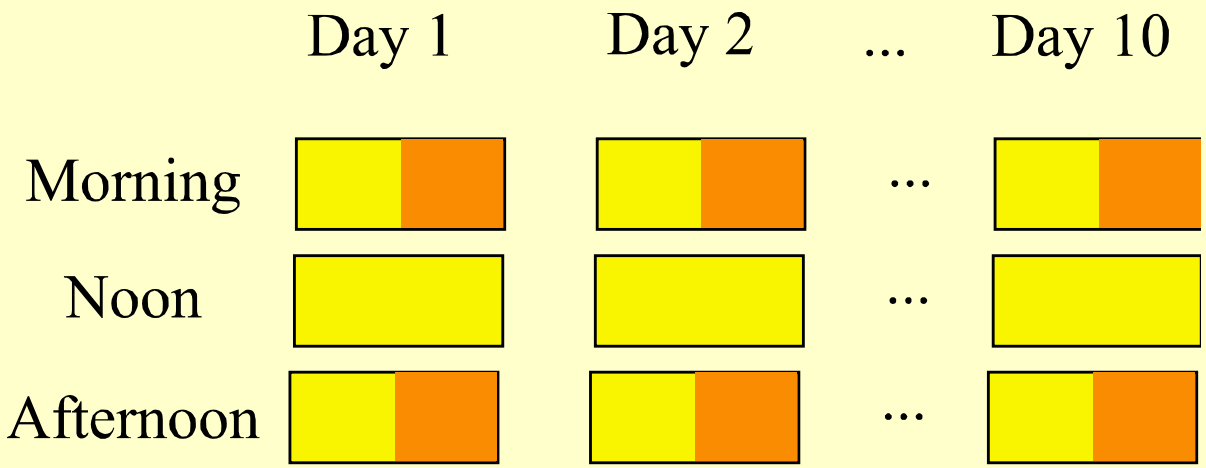
Children’s executive functions and emotions

Lo, H., Malmberg, L.-E., Heemskerk, C., Esser, P., Dawes, H., & Roebers, C. (2024). Affective and cognition dynamics in primary school classrooms: An intensive longitudinal study. *Cognition and Emotion*, doi = 10.1080/02699931.2024.2427886

Malmberg, L.-E., Lo, H., Heemskerk, C., Esser, P., Dawes, H., & Roebers, C. (2024). Intraindividual dynamics of primary school students’ executive functioning: accuracy and response-time. Manuscript for *Journal of Learning and Individual Differences*, major revision sent back 6/11

The Physical Activity, Engagement and Cognition (PEC) study

We recruited 46 Y4-6 children in March, 2020 (aiming at n = 150, Schultzberg & Muthén, 2018, when covid struck), Mage = 9.9 years



Situational measures

= Ss' learning experiences

= Executive functioning task (Hearts & Flowers)

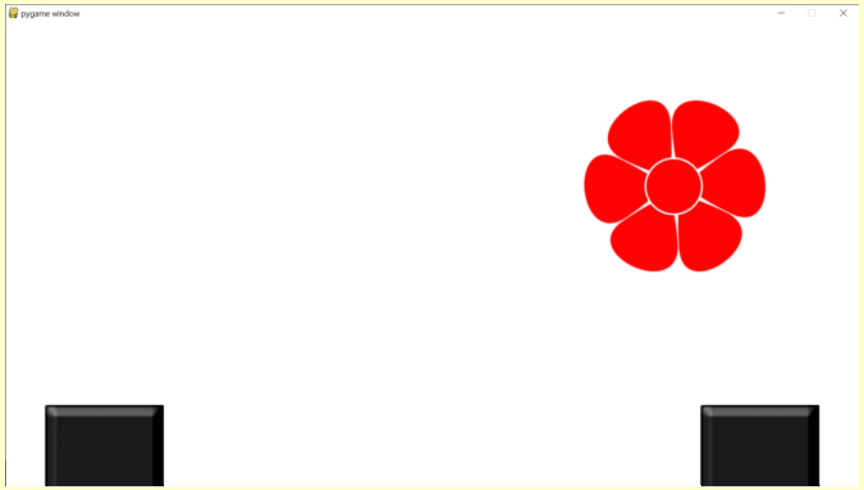
Ambulatory measures
Ss wore Accelerometer wristband up to 12 days

Person measures
Ss' Height and weight, some demographics

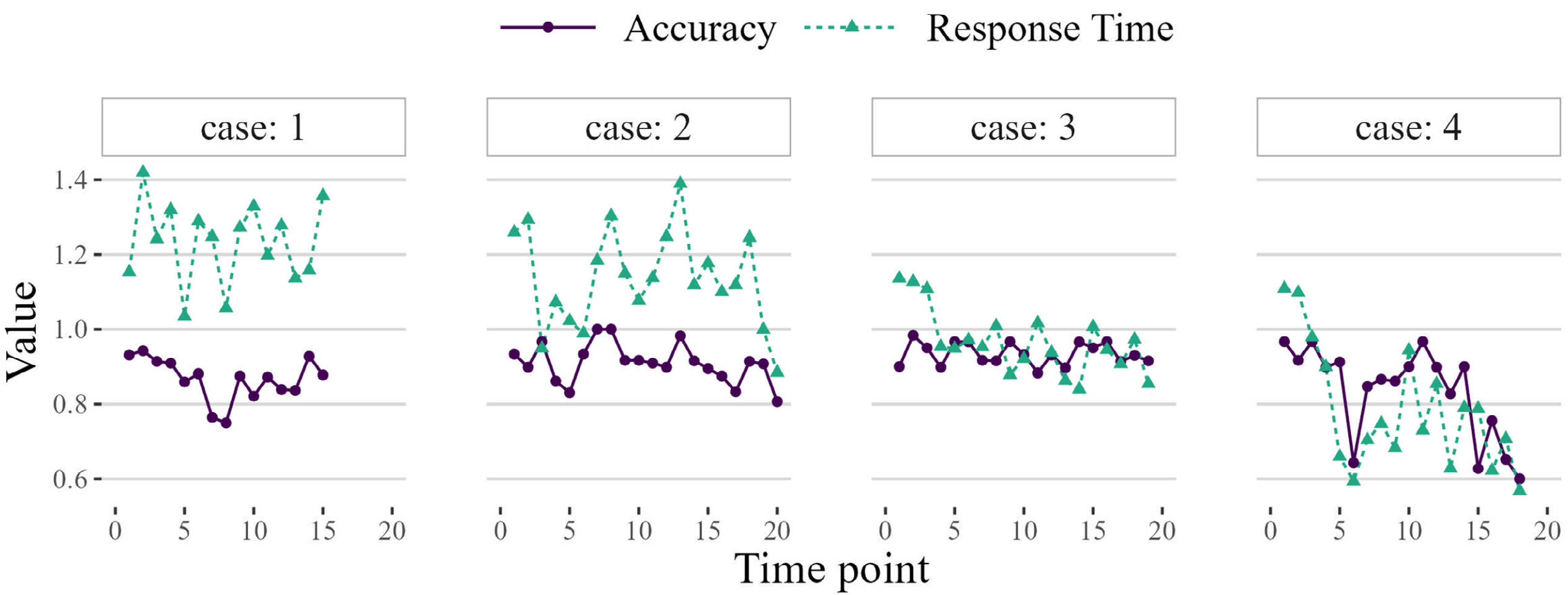
The Hearts and Flowers task (Davidson et al 2006)

Press button on the same side as the Heart

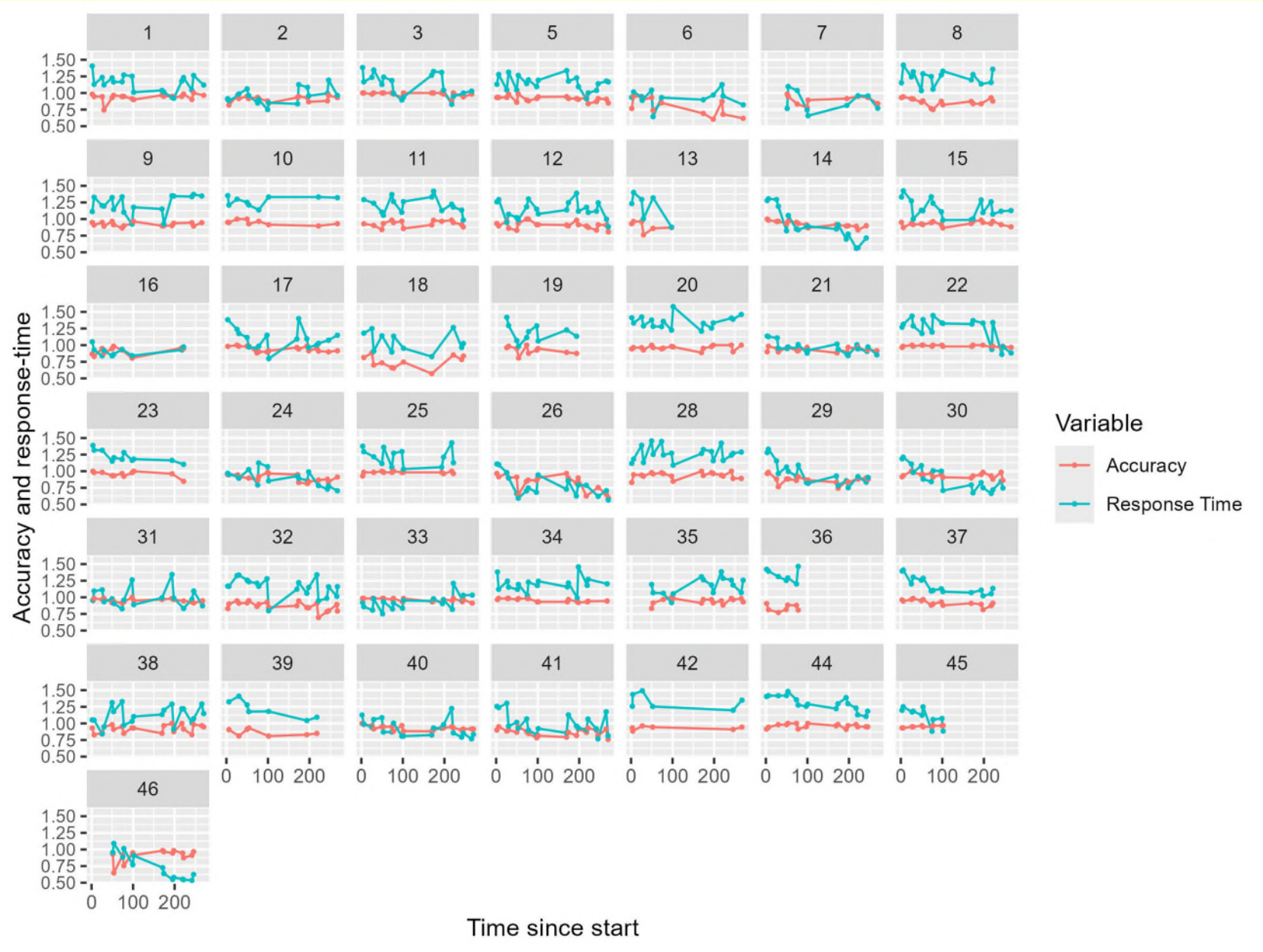
Press button on the opposite side of the Flower



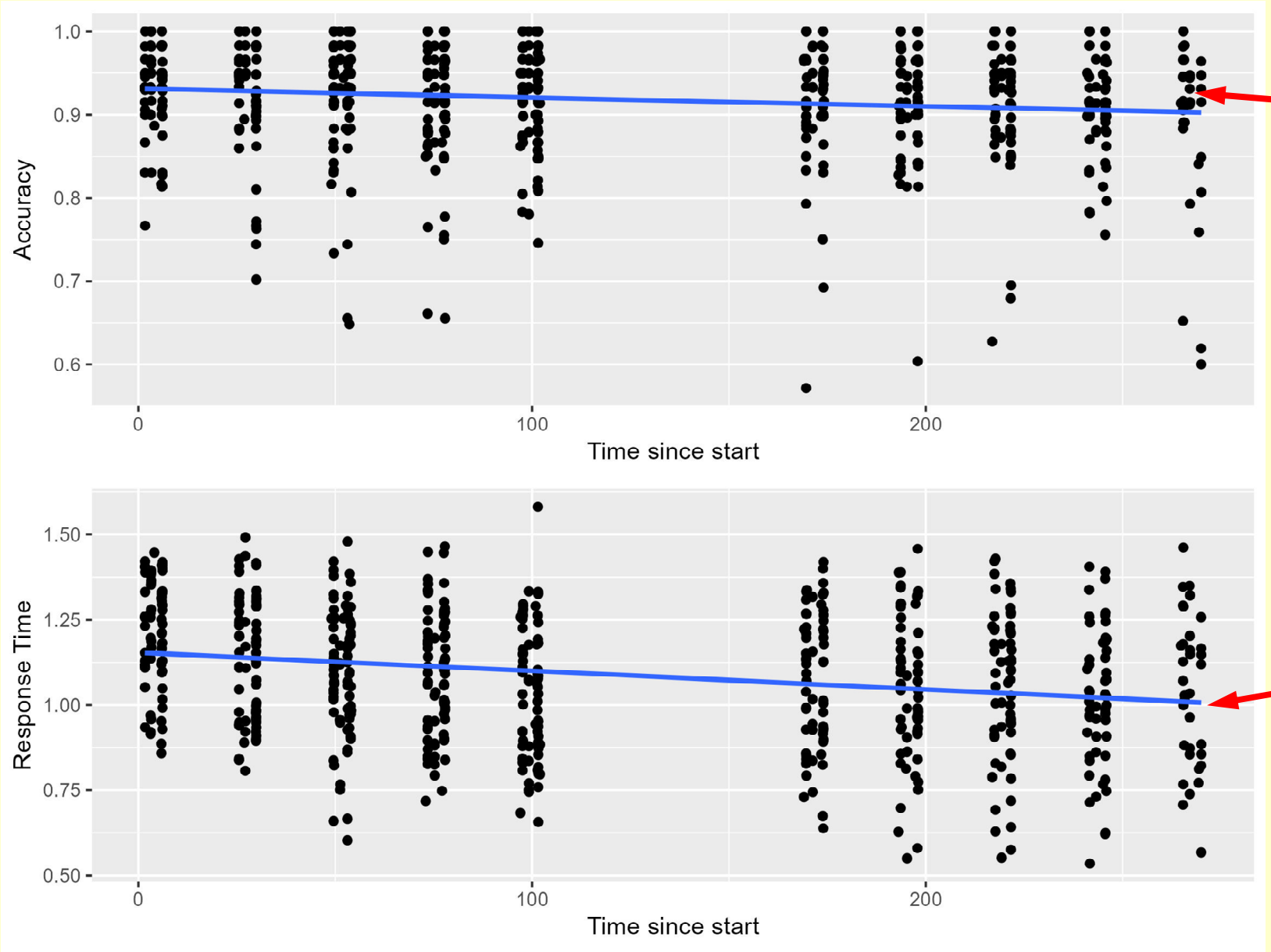
Accuracy and response-times across time (twice a day for two weeks), for four students



Individual response-times and accuracies over two weeks



Accuracy and response-time by time since start of the study



Children became less accurate over time

Children became faster over time

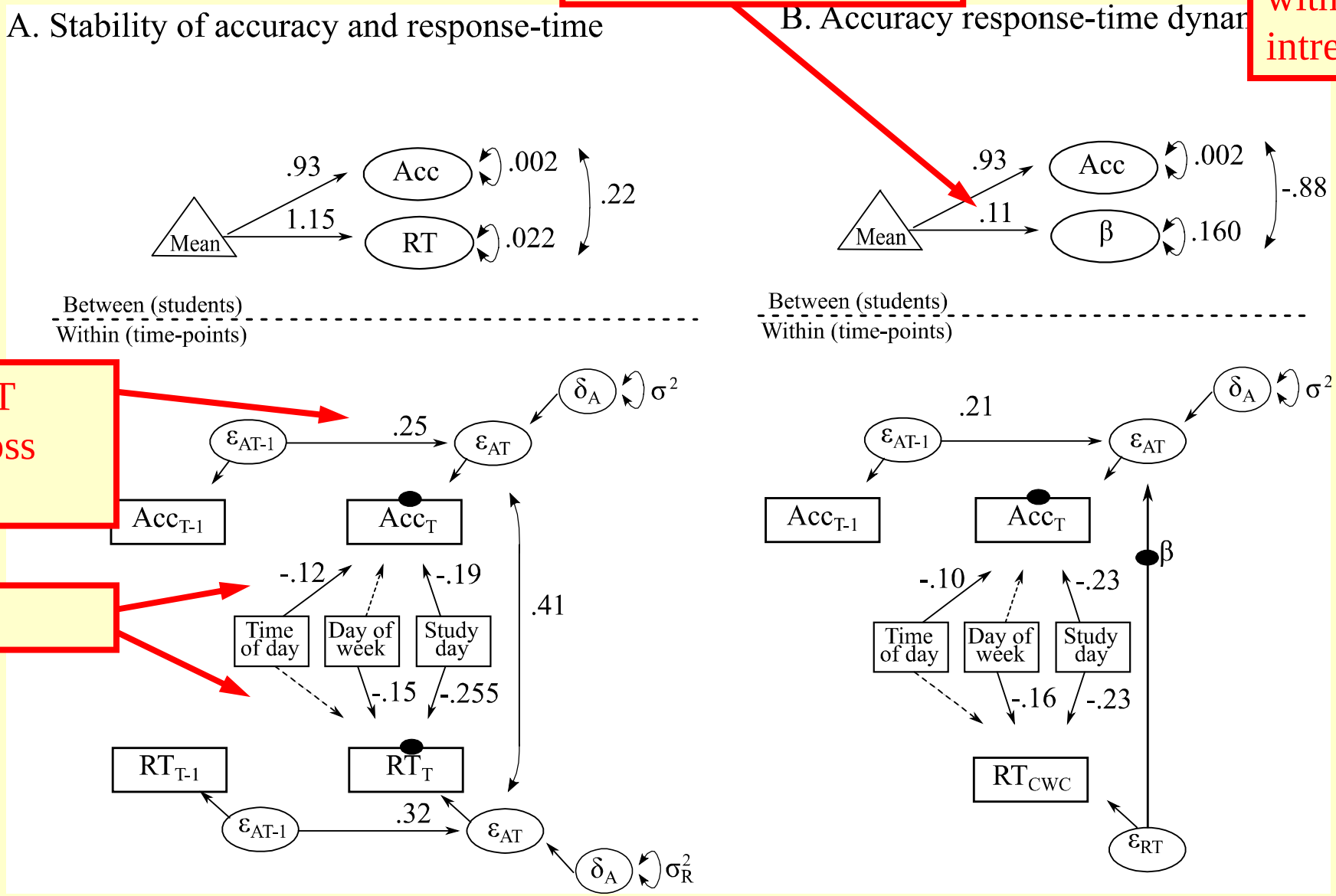
RDSEM

Accuracy-on-RT-slopes credible, with large variance

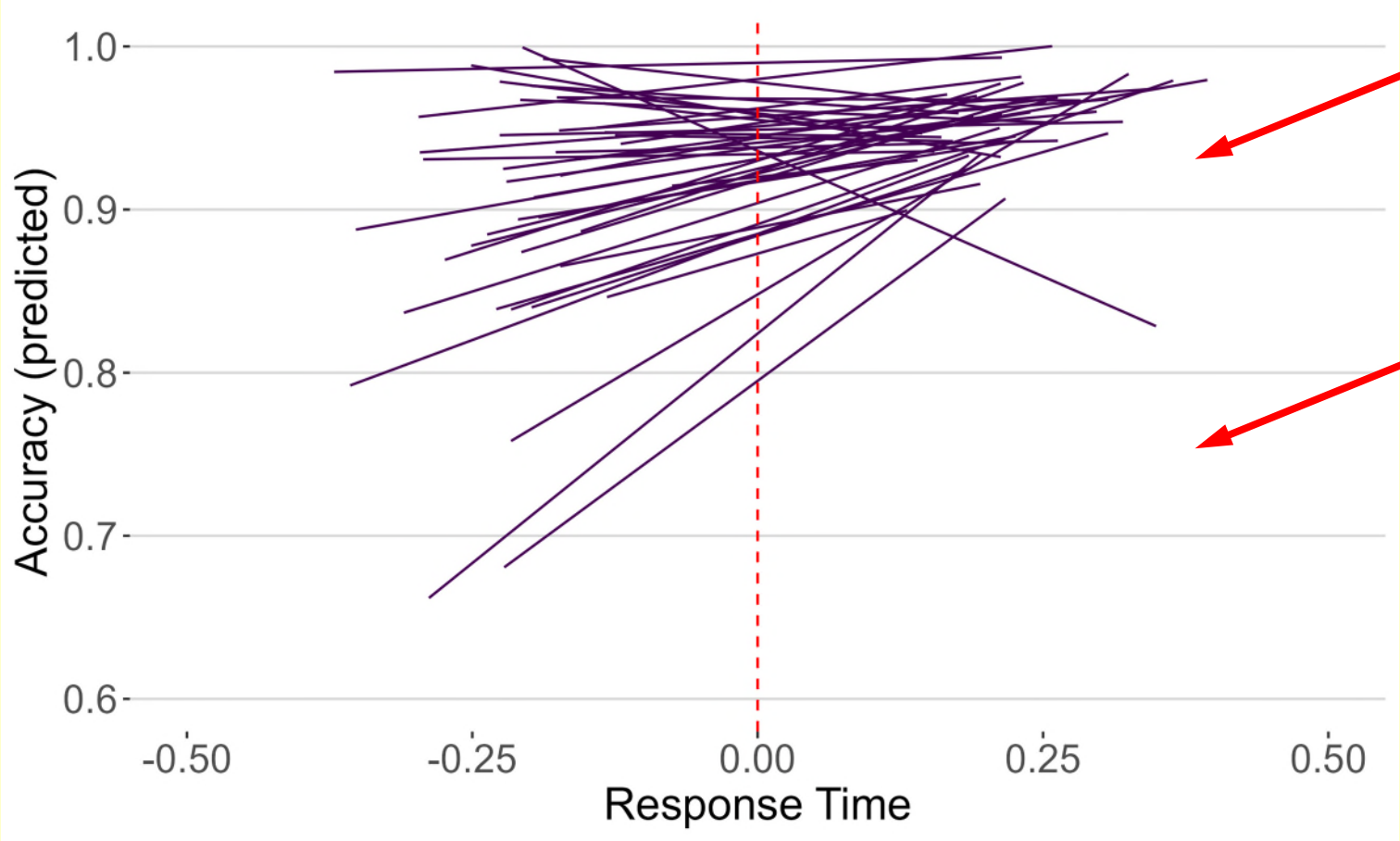
Larger accuracy-on-RT-slopes associated with lower accuracy intrercepts

Accuracy and RT fairly stable across time

Time-effects



Individual differences in accuracy-on-response-time slopes



Larger accuracy-on-RT-slopes associated with lower accuracy intrercepts

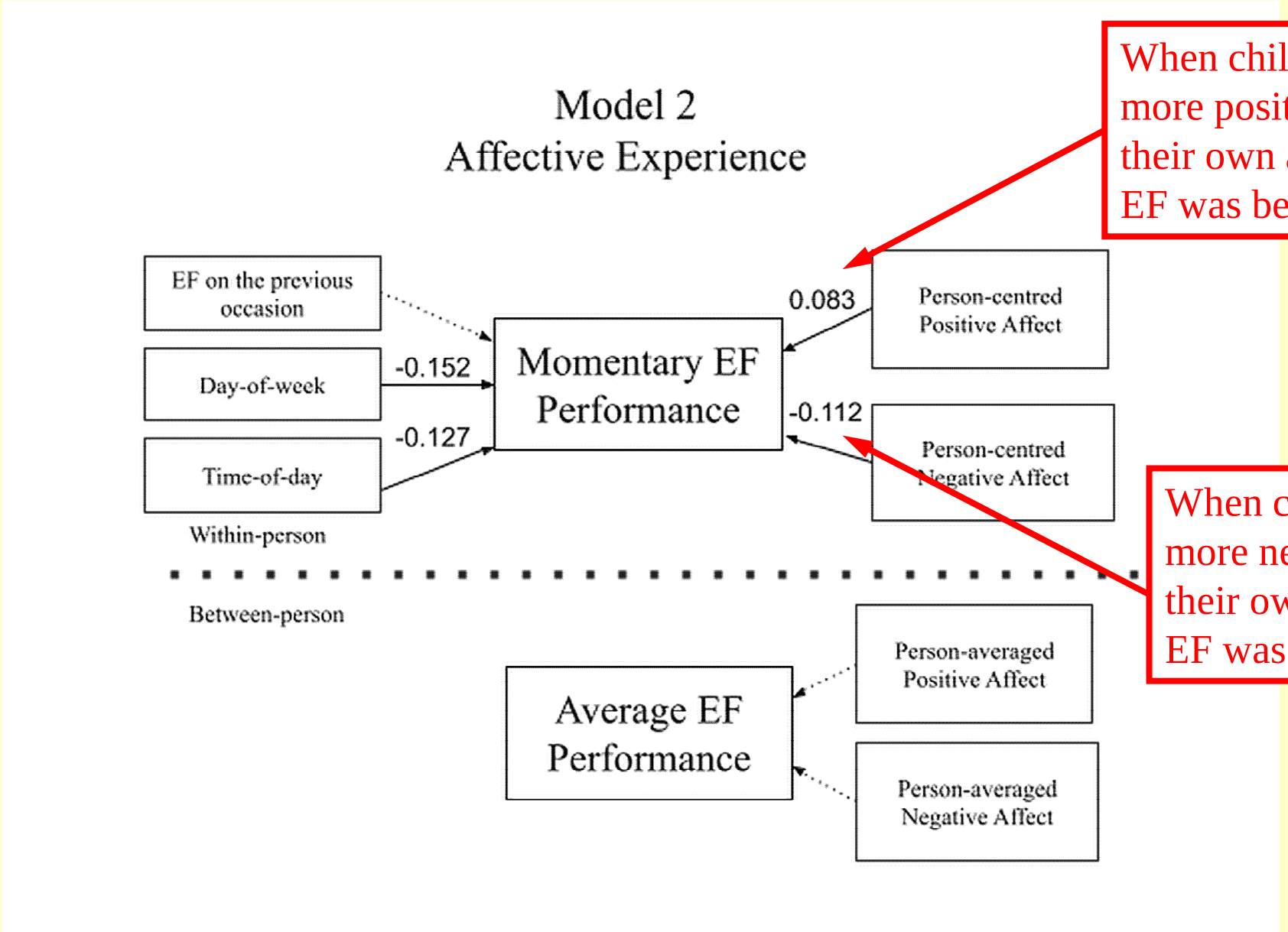
When children with lower trait-accuracy slow down, they are more accurate

Executive functions and affect (Lo et al, 2024)

* Cognitive load theory: affective states universally compromise EF by overloading cognitive capacity
* Attention Control Theory: negative affect, specifically anxiety, undermines EF by reallocating attentional resources, diminishing the capacity for EF tasks
* Broaden-and-build theory: positive affect facilitates cognitive functions, fostering greater engagement in exploratory and integrative activities, which can enhance future cognitive resources but may impede performance in tasks requiring focussed attention.

Composite scores for positive affect (active, calm, cheerful, excited, and relaxed), and negative affect (angry, annoyed, bored, frustrated, and sad) on five-point scales (1 = not at all, 5 = very much)

EF (accuracy) and emotions (Lo et al, 2024)



5. Summary

Summary and implications for practice

* An intraindividual approach can get us rich process data for students, teachers, and student-teacher interactions

* All students and teachers have ups and downs – how can teachers capitalise on teachable moments of all students?

* How can “downs” be transformed into “ups”?

Challenges

* Time-consuming and complex data-collection

* Advanced modelling

Possible future design: Follow students when working in class and in an online portal (e.g., Ville)

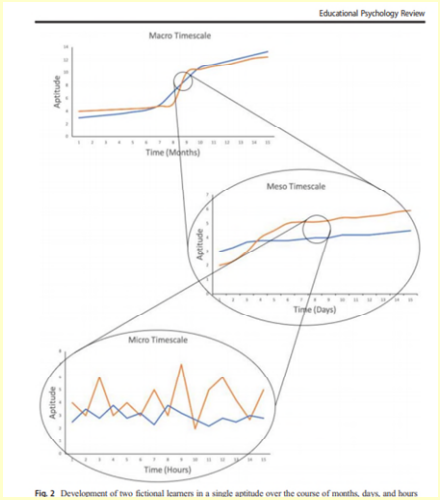
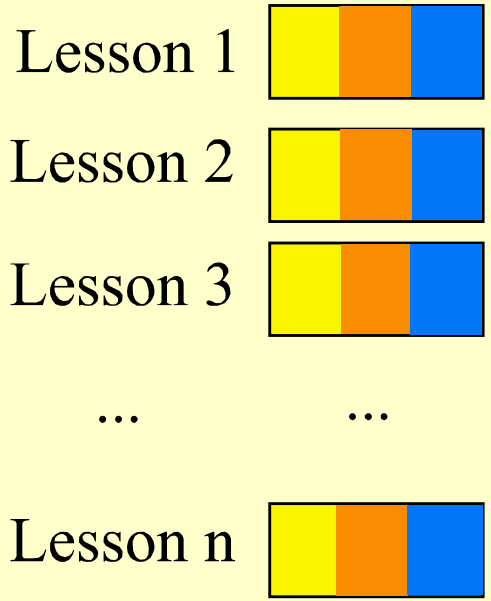


Fig. 2 Development of two fictional learners in a single aptitude over the course of months, days, and hours



Situational measures

= Ss' self-reports in classroom work

= S's self-reports in learning portal

= Learing task reports:
accuracy, response-times
trace data, meta data

On-going statistical debate

Sample sizes: n_i = 150+ (Shultzberg & Muthén, 2018), n_{ti} matters less

n_i = 10-50 with informative priors (McNeish, 2019)

Simulation studies for priors

Sparce data at the between-level gives estimation problems for variances

Bayesian estimator: “just another estimator” or embrace whole philosophy of priors? (Muthén & Asparouhov, 2012)

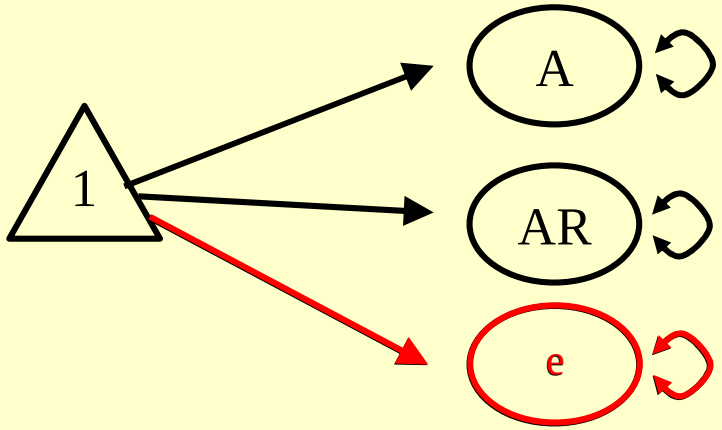
Where is the big world out there heading?

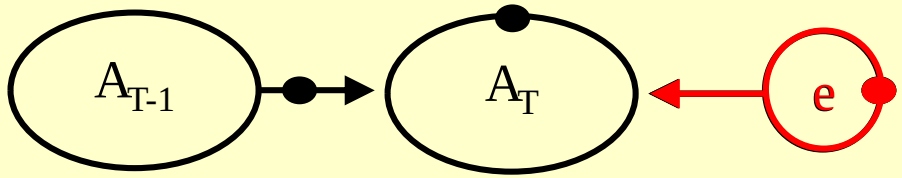
* Nudge designs (Breitwieser et al., 2021)
* Increased integration with AI and machine learning
* Network analyses

Method innovations

* How to model night-time / down-time
* Time covariates and/or RDSEM?
* Volatility and innovation constructs and their interpretation

Individual differences in residuals





Include predictors of volatility

Volatility to anything that is not measured by the predictors: stress sensitivity to the “outside world” (Jongerling et al 2015)

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Kiitos! Tack!

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