Using Log-file Based Process Measures as Indicators of Task Engagement in Digital Reading: Perspectives and Problems

Beyond Results, 6/17/2020

Johannes Naumann

University of Wuppertal
School of Education
Institute of Educational Research

BERGISCHE UNIVERSITÄT WUPPERTAL

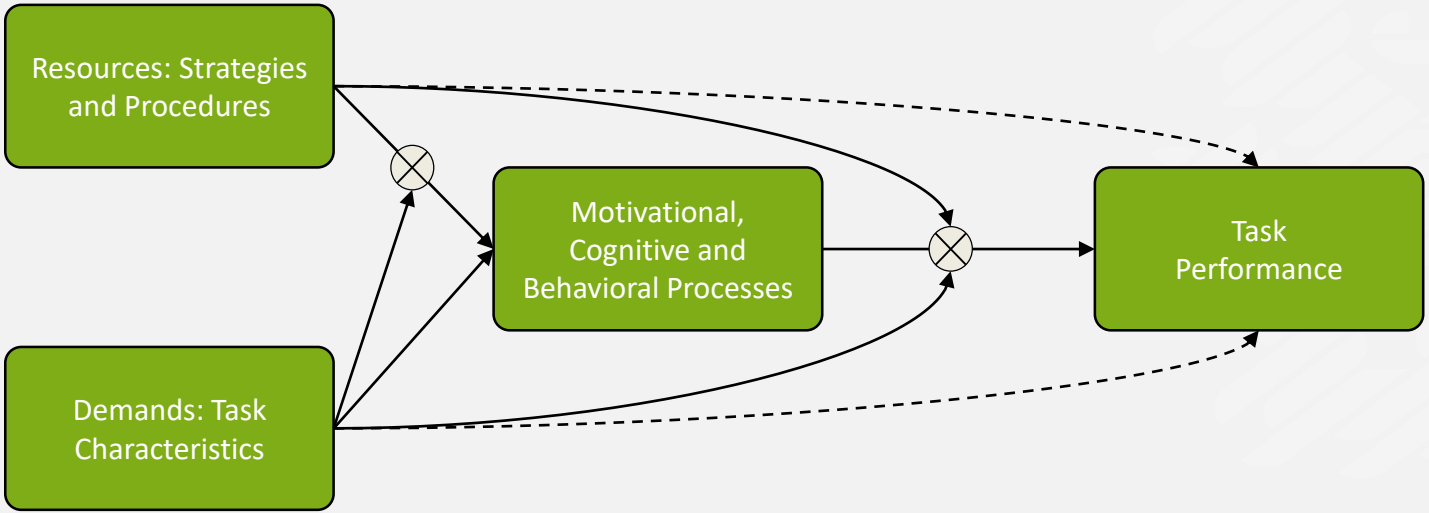
Process measures in digital reading

- As everybody in this “Room” knows: Movement towards computer-based (reading) assessments makes process data available (in the first place, but not confined to, log files):
  - Substantiate cognitive models of test performance
  - Craft validity arguments
  - Test substantive theories that entail assumptions about cognitive or behavioral processes in the domains targeted by educational assessments
- Requires, however, psychologically meaningful indicators that are derived from potentially ambiguous process data

Process measures in digital reading: Outline

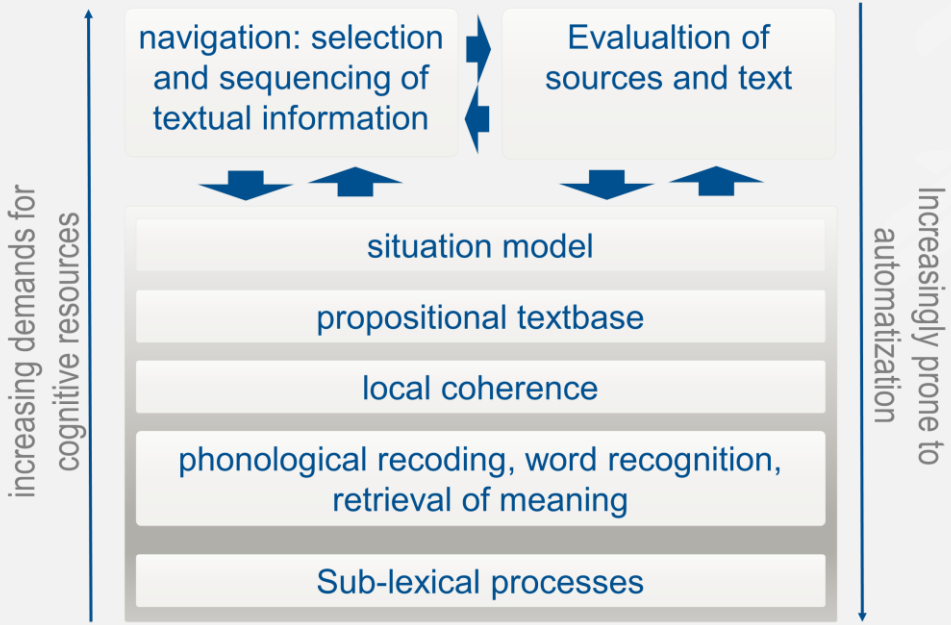
1. A very comprehensive model, accounting for ambiguity
2. Empirical results I: Predicting performance from processes – here: Time-on-task
3. Empirical results II: Predicting processes from person and task characteristics
   a. Predicting time-on-task
   b. Predicting navigation behavior
4. A wrap-up.

A very comprehensive model



Empirical results I: Predicting performance

- Reading, digital reading, and processing requirements (e.g. Naumann & Goldhammer, 2017; Naumann & Salmerón, 2016; Salmerón, Naumann, García, & Fajardo, 2017):



Empirical results I: Predicting performance

- Prominent process measure: Time on task – is, however, potentially indicative for both
  - Automatization
  - Strategic allocation of cognitive resources

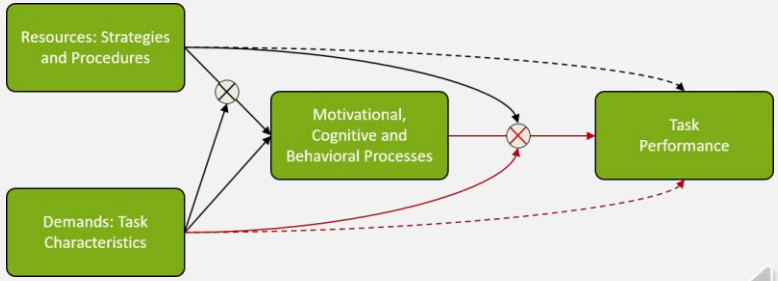
➔ Contrary theoretical interpretation, implying different associations between time on task and performance

Empirical results I: Predicting performance

Time-on-task effects in digital reading moderated by task demands?

- Easy tasks with prevalence of processes amenable to automatiziation: Negative time-on-task effects (e.g. Richter, Isberner, Naumann, & Kutzner, 2012; Richter, Isberner, Naumann, & Neeb, 2013; Naumann, Neeb, Richter, Knoepke, & Isberner, 2016)

- Hard tasks with complex texts and/or high navigation demands: Positive time-on-task effects (e.g. Goldhammer, Naumann et al., 2014; Goldman, Braasch, Wiley, Graesser, & Brodowinska, 2012)

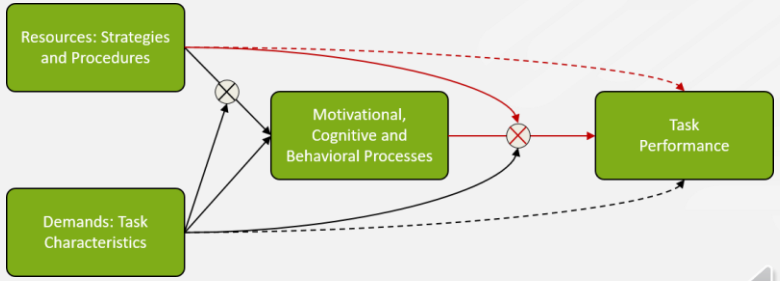


Empirical results I: Predicting performance

Time-on-task effects moderated by person skills?

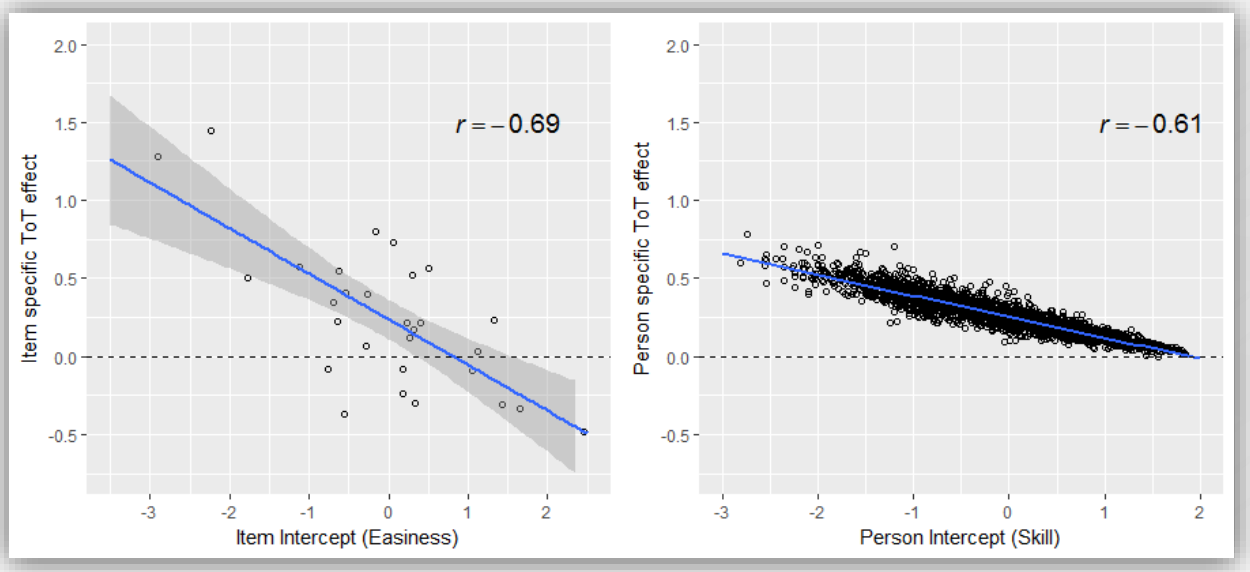
- Weak readers can compensate for lack of automatization in basic reading processes by investing more time: Positive time-on-task effects (e.g. Walczyks, 2000, compensatory-encoding model)

- No such compensation needed in strong readers with well-automatized basic reading processes: no time-on-task effects (e.g. Goldhammer, Naumann et al., 2014; Perfetti, 2007; Richter, Isberner, Naumann, & Neeb, 2012, 2013)



Empirical results I: Predicting performance

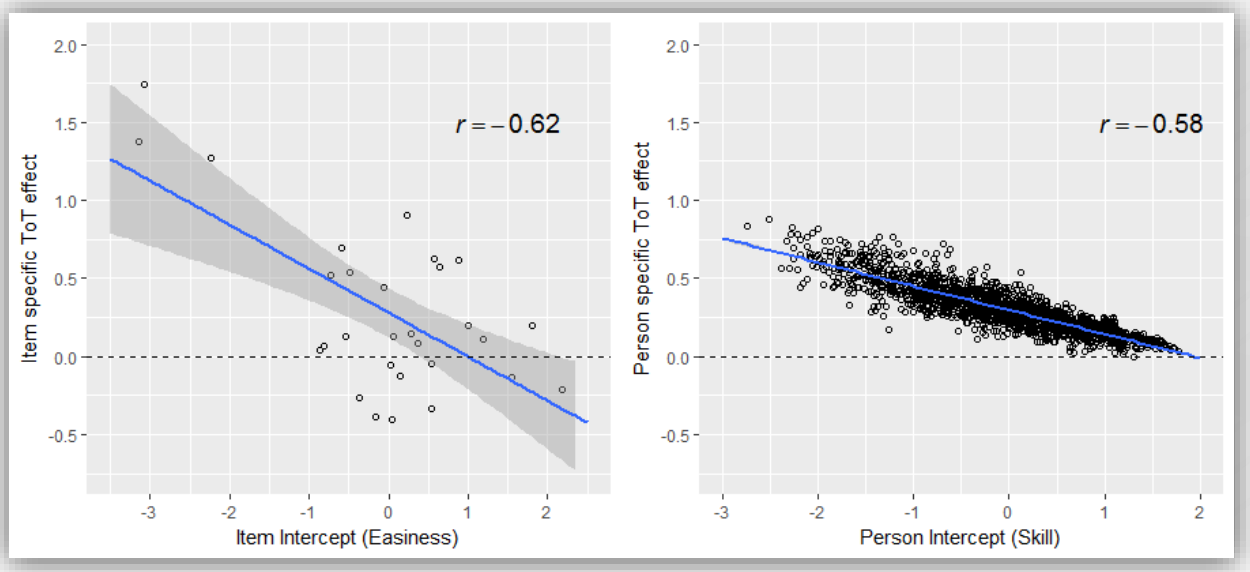
- Belgium 2009 (Naumann & Goldhammer, 2017)



$$ln\left(\frac{p_{ipu}}{1-p_{ipu}}\right) = \beta_0 + b_{0i} + b_{0p} + \left(\beta_1 + b_{1i} + b_{1p}\right) \cdot (time\ on\ task) + b_{0u}$$

Empirical results I: Predicting performance

- New Zealand 2009 (Naumann & Goldhammer, 2017)



$$ln\left(\frac{p_{ipu}}{1-p_{ipu}}\right) = \beta_0 + b_{0i} + b_{0p} + \left(\beta_1 + b_{1i} + b_{1p}\right) \cdot (time\ on\ task) + b_{0u}$$

Interlude 1

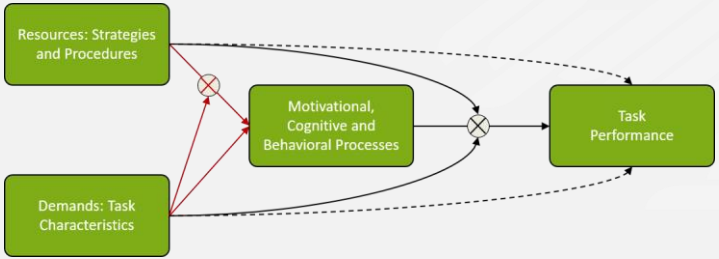
Adapting time on task in digital reading to
Task difficulty is beneficial – but who does it,
Anyway?

Empirical results II: Predicting processes (a. time-on-task)

- Task adaptive time on task behavior in digital reading requires
  - An adequate task model (see Rouet, Britt, & Durik‘s, 2017, RESOLV model)
    > enabled by good comprehension skills (e.g. Hahnel, Goldhammer, Naumann, & Kröhne, 2018; Maña, Vidal-Abarca, & Salmerón, 2017; Salmerón, Cerdán, & Naumann, 2015)
  - Metacognitive regulation through the process of task engagement
    > enabled by knowledge of reading strategies (see e.g. Artelt, Naumann, & Schneider, 2010; Pressley, Borkowski, & Schneider, 1989; Winne & Hadwin, 1998; Son & Metcalfe, 2000)
  - Self-control
    > enabled by reading enjoyment, as e.g. indicated by position effects being moderated by reading enjoyment (e.g. Nagy, Nagengast, Becker, Rose, & Frey 2018; Lindner, Nagy, Ramos Arhuis, & Retelsdorf, 2017)

Empirical results II: Predicting processes (a. time-on-task)

- Association of task difficulty and time on task in reading digital text is moderated by
  - Comprehension skill
  - Knowledge of reading strategies
  - Reading enjoyment
- Ordinal interactions: Positive association between time on task and task difficulty stronger in persons high in each variable



Empirical results II: Predicting processes (a. time-on-task)

- Model (estimated individually for each country, fixed effects integrated meta-analytically, random-effects model):

```
Time on task ~ difficulty *
               comprehension skill *
               strategy knowledge *
               reading enjoyment +

               difficulty*SES +
               difficulty*gender +

               (1 | person) +
               (1 | item) +
               (1 | school)
```

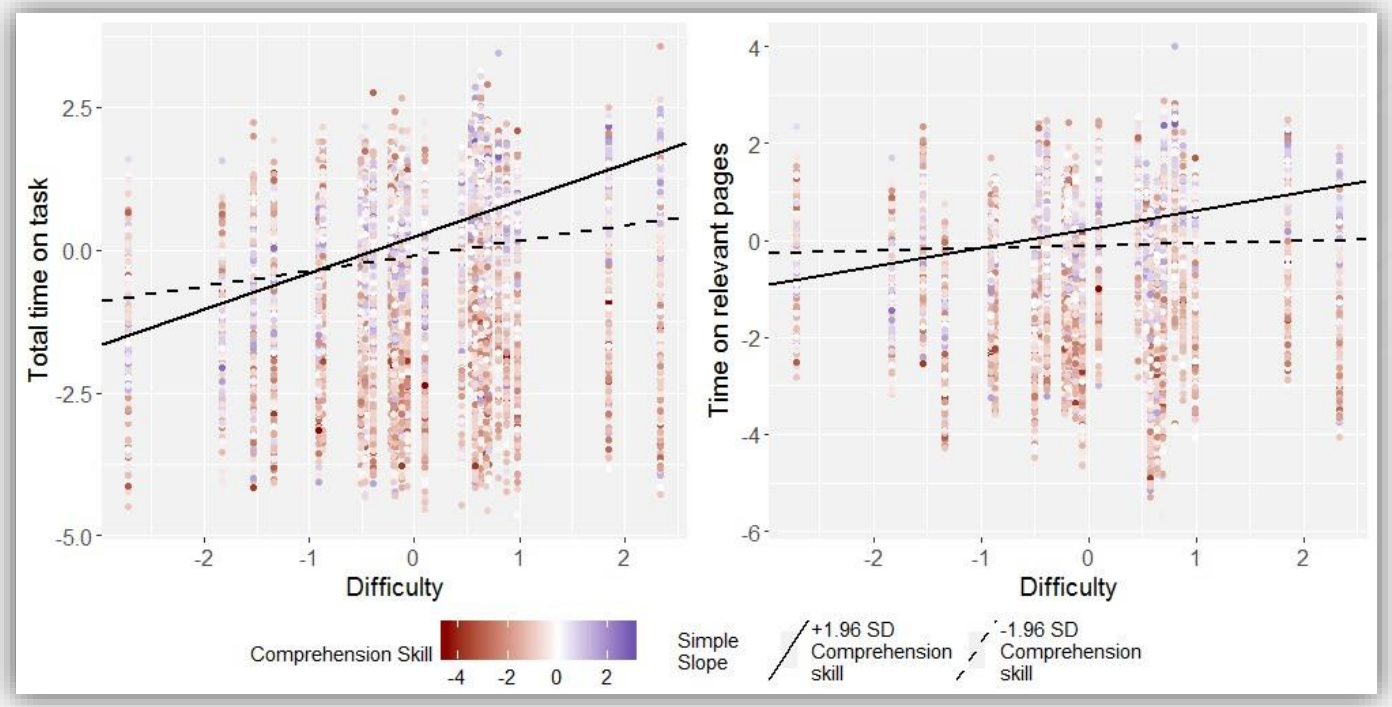
All main effects, two, three, and four way interactions (fixed)

main effects and two-way interaction with difficulty (fixed)

random effects for persons, items schools

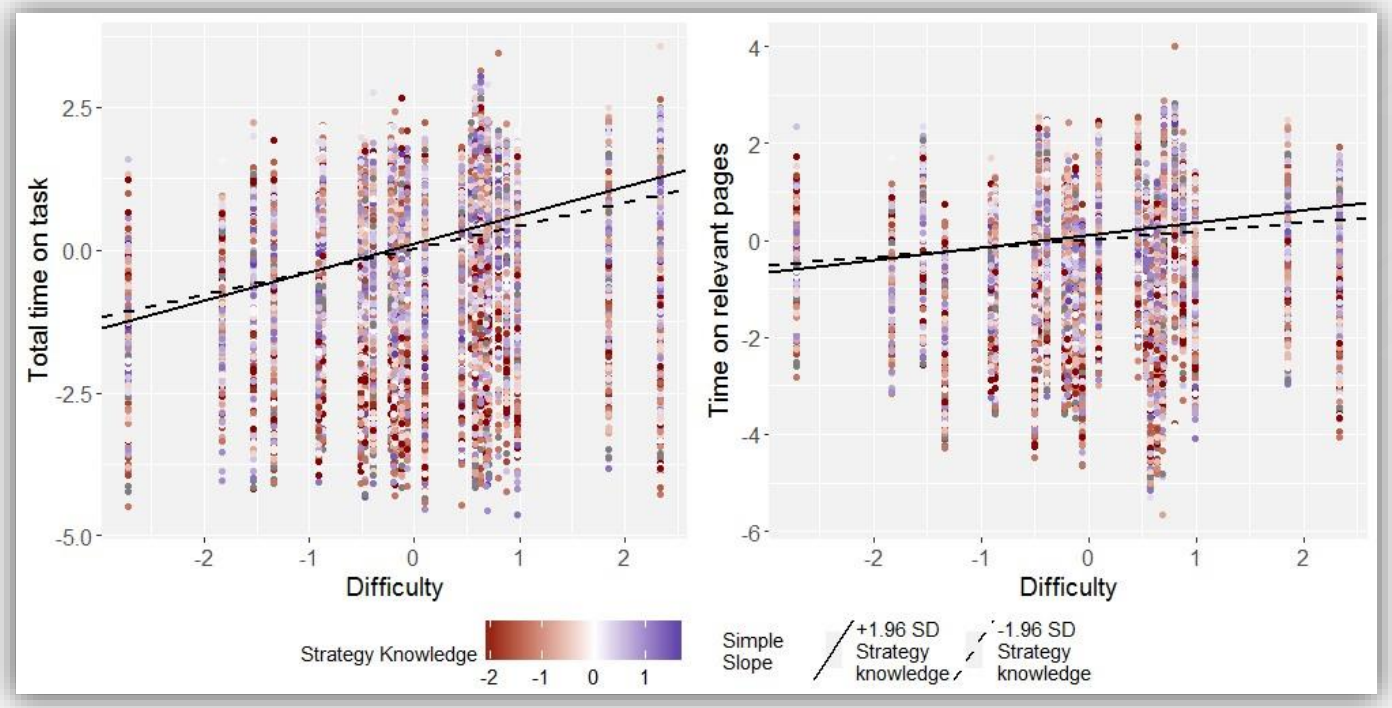
Empirical results II: Predicting processes (a. time-on-task)

- Interaction difficulty x comprehension skill – Illustration (AUS)



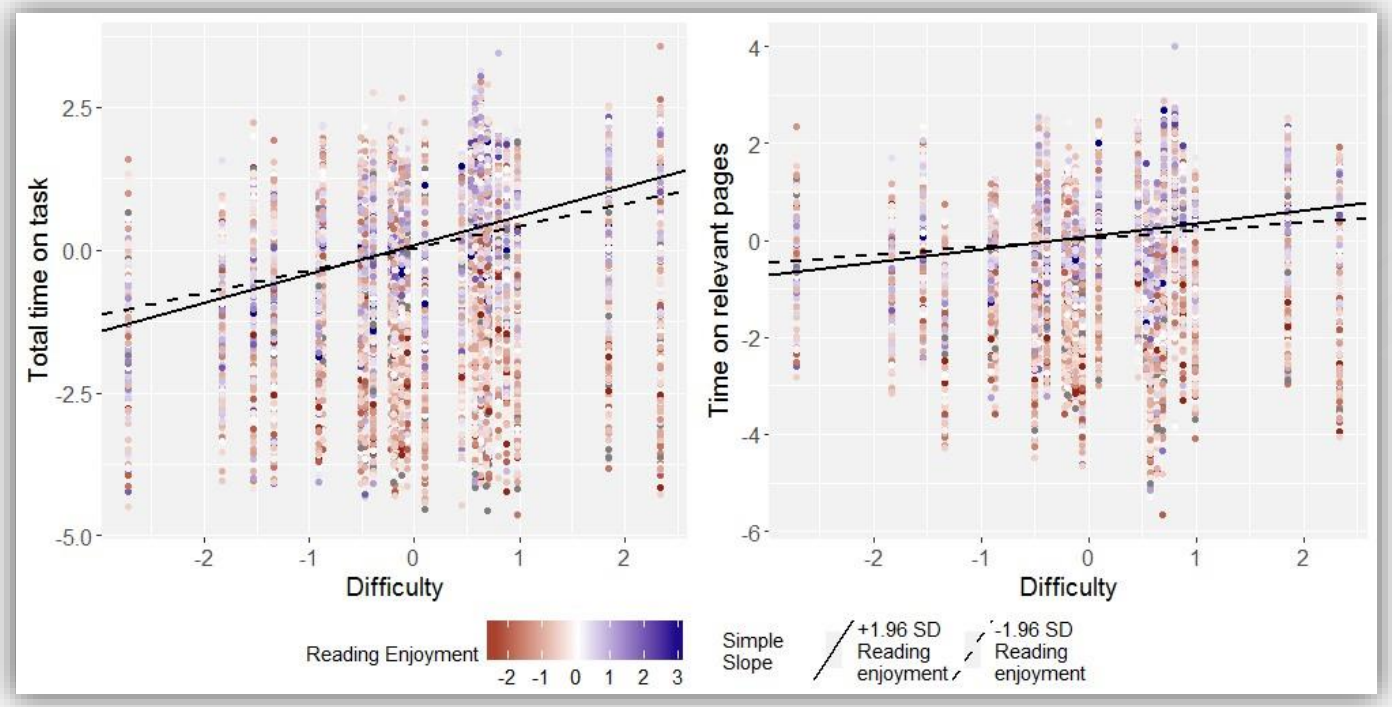
Empirical results II: Predicting processes (a. time-on-task)

- Interaction difficulty x knowledge of reading strategies – Illustration (AUS)



Empirical results II: Predicting processes (a. time-on-task)

- Interaction difficulty x enjoyment of reading – Illustration (AUS)



Empirical results II: Predicting processes (a. time-on-task)

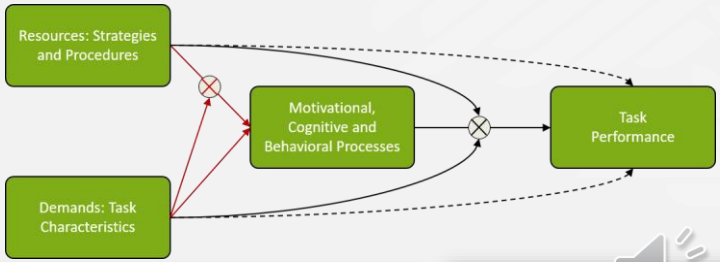
- Skilled (comprehension), knowledgeable (reading strategies) and motivated (reading enjoyment) students more apt at aligning their time on task behavior with task demands
- One possible mechanism by witch positive correlations between readers' comprehension skill/strategy knowledge/reading enjoyment and digital reading performance unfold
- Threat to validity? – depends on what is part of the construct
  - Comprehension skill and strategy knowledge: Definitely
  - Reading enjoyment: Probably not (interactions were small, though, so, maybe not too bad)

Interlude 2

Timing behavior is important – but not the only process of relevance in digital reading. We want to look at "navigation", too.

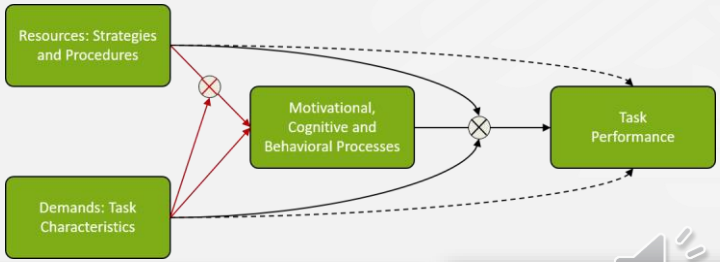
Empirical results II: Predicting processes (b. navigation)

- Crucial process in digital reading: “Navigation” (Hahnel, Goldhammer, Naumann, & Kröhne, 2016; Lawless & Schrader, 2008; Naumann, 2015; Naumann & Salmerón, 2016; OECD, 2011; Salmerón, Cerdán, & Naumann, 2015)
- Navigation cognitively demanding (DeStefano & Levefre, 2007; Naumann, Richter, Christmann & Groeben, 2007; Naumann, Richter, Flender, Christmann, & Groeben, 2008)
- “Engaged” readers (see Gutrie, Wigfield, & You, 2012) through practice more apt to cope with digital reading navigation demands?



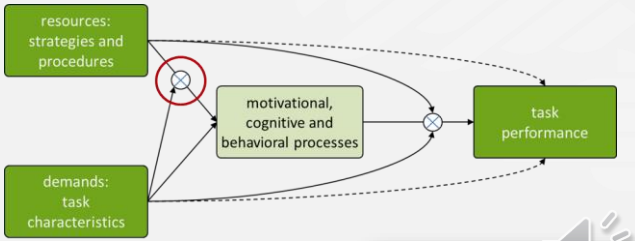
Empirical results II: Predicting processes (b. navigation)

- Online reading engagement: 2 Dimensions
  - „Social“ Engagement:
    - Frequent use of E-Mail, Social Networks, and Messaging services
    - Negative associations with academic achievement (e.g. Jacobsen & Forste, 2011; Junco, 2012a,b; Kirschner & Karpinski, 2010; Pfost, Dörfler, & Artelt, 2013)
  - „Information“ Engagement:
    - Frequent use of online-encyclopedia, dictionaries or news websites
    - Positive associations with achievement (?)

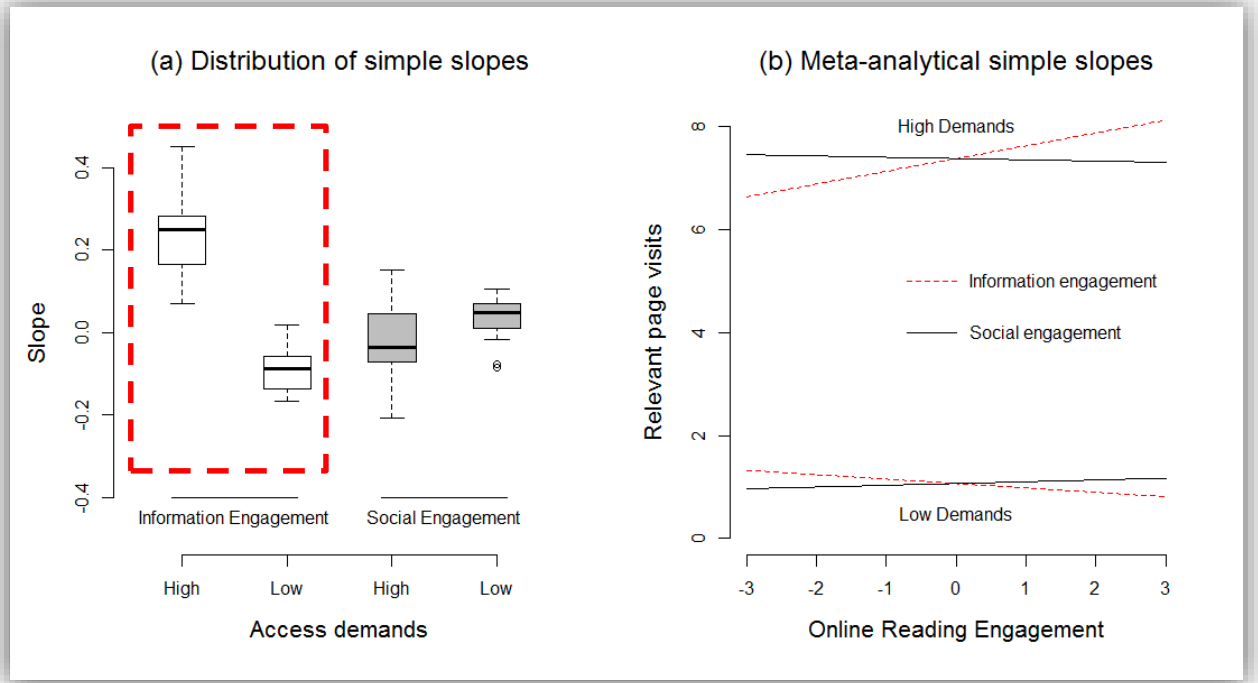


Empirical results II: Predicting processes (b. navigation)

- Hypotheses (substantive)
  - More adaptive navigation with more information engagement
  - Less adaptive navigation with more social engagement
- Statistically:
  - Positive interaction between navigation demands and information engagement
  - Negative interaction between navigation demands and social engagement



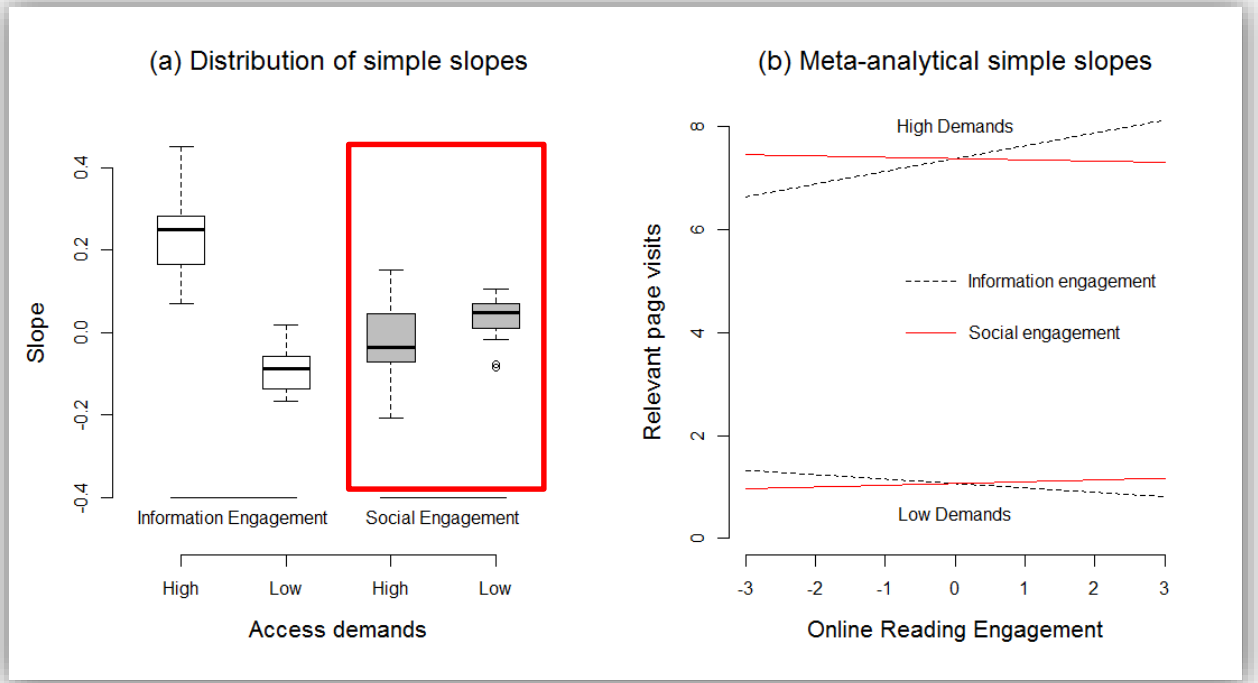
Empirical results II: Predicting processes (b. navigation)



$$\text{navigation}_{ips} = b_0 + \beta_1(\text{information engagement}) + \beta_2(\text{social engagement}) + \beta_3(\text{access demands}) + \beta_4(\text{information engagement} \times \text{access demands}) + \beta_5(\text{social engagement} \times \text{access demands}) + \beta_6(\text{reading skill}) + \beta_7(\text{ICT at home}) + \beta_8(\text{ICT at school}) + \beta_9(\text{gender}) + \beta_{10}(\text{SES}) + b_{0i} + b_{0p} + b_{0s} + \varepsilon_i$$

Figure from: Naumann (2015), p. 272

Empirical results II: Predicting processes (b. navigation)



$$\text{navigation}_{ips} = b_0 + \beta_1(\text{information engagement}) + \beta_2(\text{social engagement}) + \beta_3(\text{access demands}) + \beta_4(\text{information engagement} \times \text{access demands}) + \beta_5(\text{social engagement} \times \text{access demands}) + \beta_6(\text{reading skill}) + \beta_7(\text{ICT at home}) + \beta_8(\text{ICT at school}) + \beta_9(\text{gender}) + \beta_{10}(\text{SES}) + b_{0i} + b_{0p} + b_{0s} + \varepsilon_i$$

Figure from: Naumann (2015), p. 272

Wrap-it-all-up

- Perspectives (as far as this talk went…)?
  - In substantive model building and testing: mind the gap (between input situation and person variables and outcomes). Log-data based process measures can help to narrow the gap, if not close it
  - In measurement:
    - Craft validity arguments – or
    - Challenge validity by showing that construct-*irrelevant* dispositions might impact on-task behavior
- Problems (as far as this talk went…)?
  - Be sure about what your log-file based process measure actually means in psychological terms
    - More difficult than it might seem:
      - Large interactions between process measures and person/task variables in predicting performance
      - Large or medium sized interactions between person and task variables in predicting processes

References

Artelt, C., Naumann, J., & Schneider, W. (2010). Lesemotivation und Lernstrategien [Reading motivation and learning strategies]. In E. Klieme, C. Artelt, J. Hartig, N. Jude, O. Köller, M. Prenzel,. . . P. Stanat (Eds.), PISA 2009: *Bilanz nach einem Jahrzehnt* (pp. 73–112). Münster: Waxmann.

DeStefano, D., & LeFevre, J.-A. (2007). Cognitive load in hypertext reading: A review. *Computers in Human Behavior, 23*, 1616–1641. https://doi.org/10.1016/j.chb.2005.08.012

Dörner, D., & Funke, J. (2017). Complex Problem Solving: What it is and what it is not. *Frontiers in Psychology, 8*, 1153. https://doi.org/10.3389/fpsyg.2017.01153

Goldhammer, F., Naumann, J., Stelter, A., Tóth, K., Rölke, H., & Klieme, E. (2014). The time on task effect in reading and problem solving is moderated by task difficulty and skill: Insights from a computer-based large-scale assessment. *Journal of Educational Psychology, 106*, 608–626. https://doi.org/10.1037/a0034716

Goldman, S. R., Braasch, J. L. G., Wiley, J., Graesser, A. C., & Brodowinska, K. (2012). Comprehending and Learning From Internet Sources: Processing Patterns of Better and Poorer Learners. *Reading Research Quarterly, 47*, 356–381.

Guthrie, J. T., Wigfield, A., & You, W. (2012). Instructional Contexts for Engagement and Achievement in Reading. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of Research on Student Engagement* (pp. 601–634). Boston, MA: Springer US. https://doi.org/10.1007/978-1-4614-2018-7_29

Jacobsen, W. C., & Forste, R. (2011). The wired generation: Academic and social outcomes of electronic media use among university students. *Cyberpsychology, behavior and social networking*, *14*, 275–280. https://doi.org/10.1089/cyber.2010.0135

Junco, R. (2012a). The relationship between frequency of Facebook use, participation in Facebook activities, and student engagement. *Computers & Education, 58*, 162–171. https://doi.org/10.1016/j.compedu.2011.08.004

Junco, R. (2012b). Too much face and not enough books: The relationship between multiple indices of Facebook use and academic performance. *Computers in Human Behavior, 28*, 187–198. https://doi.org/10.1016/j.chb.2011.08.026

References

Kirschner, P. A., & Karpinski, A. C. (2010). Facebook® and academic performance. Computers in Human Behavior, 26, 1237–1245. https://doi.org/10.1016/j.chb.2010.03.024

Lawless, K., & Schrader, P. G. (2008). Where do we go now? In J. Coiro, M. Knobel, C. Lankshear, & D. J. Leu (Eds.), *Handbook of research on new literacies* (pp. 267–296). New York, NY: Routledge.

Lindner, C., Nagy, G., & Retelsdorf, J. (2018). The need for self-control in achievement tests: Changes in students' state self-control capacity and effort investment. *Social Psychology of Education, 21*, 1113–1131. https://doi.org/10.1007/s11218-018-9455-9

Mañá, A., Vidal-Abarca, E., & Salmerón, L. (2017). Effect of delay on search decisions in a task-oriented reading environment. *Metacognition and Learning, 12*, 113–130. https://doi.org/10.1007/s11409-016-9162-x

Mayer, R. E., & Wittrock, M. C. (2006). Problem solving. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (2nd ed., pp. 287–304). Mahwah, NJ: Erlbaum.

Nagy, G., Nagengast, B., Becker, M., Rose, N., & Frey, A. (2018). Item position effects in a reading comprehension test: An IRT study of individual differences and individual correlates. *Psychological Test and Assessment Modeling, 60*, 165–187.

Naumann, J., Goldhammer, F., & Elson, M. *Educational assessment and model building using process data: Issues of open science and replication*, Manuscript in in preparation.

Naumann, J., Neeb, Y., Richter, T., Isberner, M.-B., & Knoepke, J. (2016, July). *Time on task eccects in low vs. high level reading tasks*. Annual Meeting of the Society for the Scientific Study of Reading, Porto, Portugal.

Naumann, J. (2015). A model of online reading engagement: Linking engagement, navigation, and performance in digital reading. *Computers in Human Behavior, 53*, 263–277. https://doi.org/10.1016/j.chb.2015.06.051

Naumann, J., & Goldhammer, F. (2017). Time-on-task effects in digital reading are non-linear and moderated by persons' skills and tasks' demands. *Learning and Individual Differences, 53*, 1–16. https://doi.org/10.1016/j.lindif.2016.10.002

References

Naumann, J., Richter, T., Christmann, U., & Groeben, N. (2008). Working memory capacity and reading skill moderate the effectiveness of strategy training in learning from hypertext. *Learning and Individual Differences, 18*, 197–213. https://doi.org/10.1016/j.lindif.2007.08.007

Naumann, J., Richter, T., Flender, J., Christmann, U., & Groeben, N. (2007). Signaling in expository hypertexts compensates for deficits in reading skill. *Journal of Educational Psychology, 99*, 791–807. https://doi.org/10.1037/0022-0663.99.4.791

Naumann, J., & Salmerón, L. (2016). Does Navigation Always Predict Performance? Effects of navigation on digital reading are moderated by comprehension skills. *The International Review of Research in Open and Distributed Learning, 17*. https://doi.org/10.19173/irrodl.v17i1.2113

OECD. (2011). *PISA 2009 Results vol. VI: Students on line*. Paris: OECD Publishing.

Perfetti, C. (2007). Reading ability: Lexical quality to comprehension. *Scientific Studies of Reading, 11*, 357–383. https://doi.org/10.1080/10888430701530730

Pfost, M., Dörfler, T., & Artelt, C. (2013). Students' extracurricular reading behavior and the development of vocabulary and reading comprehension. *Learning and Individual Differences, 26*, 89–102. https://doi.org/10.1016/j.lindif.2013.04.008

Pressley, M., Borkowski, J. G., & Schneider, W. (1989). Good information processing: What it is and how education can promote it. International *Journal of Educational Research, 13*, 857–867. https://doi.org/10.1016/0883-0355(89)90069-4

Richter, T., Isberner, M.-B., Naumann, J., & Kutzner, Y. (2012). Prozessbezogene Diagnostik von Lesefähigkeiten bei Grundschulkindern. *Zeitschrift für Pädagogische Psychologie, 26*, 313–331. https://doi.org/10.1024/1010-0652/a000079

Richter, T., Isberner, M.-B., Naumann, J., & Neeb, Y. (2013). Lexical Quality and Reading Comprehension in Primary School Children. *Scientific Studies of Reading, 17*, 415–434. https://doi.org/10.1080/10888438.2013.764879

Rouet, J.-F., Britt, M. A., & Durik, A. M. (2017). RESOLV: readers' representation of reading contexts and tasks. *Educational Psychologist, 52*, 200–215. https://doi.org/10.1080/00461520.2017.1329015

Rouet, J.-F., & Le Bigot, L. (2007). Effects of academic training on metatextual knowledge and hypertext navigation. *Metacognition and Learning, 2*, 157–168. https://doi.org/10.1007/s11409-007-9011-z

References

Salmerón, L., Naumann, J., García, V., & Fajardo, I. (2017). Scanning and deep processing of information in hypertext: An eye tracking and cued retrospective think-aloud study. *Journal of Computer Assisted Learning, 33*, 222–233. https://doi.org/10.1111/jcal.12152

Salmerón, L., Cerdán, R., & Naumann, J. (2015). How adolescents navigate Wikipedia to answer questions. *Infancia y Aprendizaje, 38*, 435–471. https://doi.org/10.1080/02103702.2015.1016750

Son, L. K., & Metcalfe, J. (2000). Metacognitive and control strategies in study-time allocation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*, 204–221. https://doi.org/10.1037/0278-7393.26.1.204

Walczyk, J. J. (2000). The interplay between automatic and control processes in reading. *Reading Research Quarterly, 35*, 554–566. https://doi.org/10.1598/RRQ.35.4.7

Winne, P. H., & Hadwin, A. E. (1998). Studying as self-regulated learning. In A. C. Graesser, D. J. Hacker, & J. Dunlosky (Eds.), *Metacognition in educational theory and practice* (pp. 277–304). Mahwah, N.J: Erlbaum.

j.naumann@uni-wuppetal.de
http://leute.uni-wuppertal.de/~nnaumann

Thank you for your attention, looking forward to questions and discussion!