NEPS
National Educational Panel Study

Research Data

Information on Direct Measures and on Competence Testing

NEPS Starting Cohort 1 — Newborns

Education From the Very Beginning

Wave 5: 4 years

LIfBi
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Test information	
Test information	Four-year-old children were tested individually in their homes in the presence of the anchor person and the interviewer.
Test sequence	The two competence measures were administered in the following sequence: 1. Flanker task: executive control 2. Mathematical competence The children used the tablet to solve the tasks on their own.
Test duration (excluding setup)	approx. 40 minutes

Information about the administered competence measures				
Construct	**Number of tasks**	**Duration (approx.)**	**Mode of administration**	**Next assessment**
Flanker task: executive control	89 single tasks (max.)	15 minutes	visual stimuli presented on a tablet; instructions were given verbally by the interviewer	-
Mathematical competence	20 tasks (max.)	25 minutes	tasks presented on a tablet; additional physical objects	Wave 7 (2018)

Preface

The development of the individual tests is based on framework concepts. They are overarching concepts, on the basis of which education-relevant competences are to be shown consistently and coherently over the entire personal history. Therefore, the following framework concepts, which served as a basis for the development of the test tools to measure the above-mentioned constructs, are identical in the different studies.

In addition to the competence measures, which are coherently assessed across the lifespan, stage-specific measures are assessed at specific points in time at which these measures are especially meaningful (cf. Berendes, Weinert, Zimmermann, & Artelt, 2013[1]). Usually, these assessments are not repeated.

[1] Berendes, K., Weinert, S., Zimmermann, S., & Artelt, C. (2013). Assessing language indicators across the lifespan within the German National Educational Panel Study (NEPS). *Journal for Educational Research Online/Journal für Bildungsforschung Online*, *5*(2), 15–49.

Flanker task: executive control

According to Hughes and Ensor (2007), the term “executive functions” is defined as higher-order cognitive functions which underlie flexible, goal-directed behavior (Carlson, 2005). These include abilities such as inhibitory control, attentional control and working memory processes (Hughes & Ensor, 2007).

Executive functions play an important role in the development of children. For example, indicators of executive functions predict later school readiness and academic achievements (e.g., Blair & Razza, 2007; Roebers, Röthlisberger, Neuenschwander, Cimeli, Michel, & Jäger, 2014). Various studies have revealed correlations between executive functions and mathematical, reading and science skills (Latzman, Elkovitch, Young, & Clark, 2010; Rhodes, Booth, Palmer, Blythe, Delibegovic, & Wheate, 2016; Yeniad, Malda, Mesman, van Ijzendoorn, & Pieper, 2013). These relationships were found in different age groups, from kindergarten age to secondary level (Best et al., 2011). In addition, empirical findings indicate that executive functions in childhood also predict other aspects, such as health or substance addiction as well as later socioeconomic status (Moffitt et al., 2011).

The concept of executive functions encompasses various relatively heterogeneous facets and indicators. On the one hand, executive functions develop early on in life, but on the other hand they have a wide development span (Diamond, 1985; Zelazo, Frye, & Rapus, 1996; Zelazo & Müller, 2002). Zelazo and Müller (2002) revealed a development leap of executive functions between the ages of 2 and 5 years. Rueda and colleagues (Rueda, Posner, & Rothbart, 2005; Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005) found a significant development in the executive function of attentional control between the ages of 4 and 6 years. Accordingly, it seemed to be a suitable objective to examine executive functions in four-year-olds in the NEPS. In the NEPS, an age-appropriate “flanker task” was used. As further indicator of executive functions, in particular of inhibitory control, so-called tasks of delay of gratification were used; these were also implemented in Starting Cohorts 1 and 2.

The flanker task can be used to assess different facets of executive functions: on the one hand, the children’s inhibitory control and, on the other hand, their selective attention (Bauer & Zelazo, 2014). Furthermore, cognitive flexibility is assessed by incorporating a rule change in the task.

Assessment of the flanker task in Starting Cohort 1: The stimulus material was presented to the children on a tablet computer which was equipped with a reaction time keyboard developed for the NEPS. With the keyboard, it was possible to ensure high measurement accuracy of the reaction time (response latency).

Like all tasks in Starting Cohort 1, the flanker task was implemented in a child-friendly and playful way by using fish as directional indicators[2]. The tasks contain congruent (all fish look/swim in the same direction) and incongruent items (middle and outer fish look/swim in different directions). The children were instructed to press a key corresponding to the direction of the respective fish.

There are three different tasks. Before the three tasks, the children were introduced to the keyboard and the button assignment. The same task order was used for all children.

Task 1 – Flanker *focus middle*:

This task consisted of up to three practice phases with seven items each and a test phase with 30 items. The children were instructed to concentrate on the middle fish and press the corresponding button as fast as possible. In doing so, they had to ignore the direction of the outer fish. The difference between the congruent and incongruent trials indicates how well the children managed to focus only on

[2] The flanker task for the NEPS was developed and validated in cooperation with the working group of Prof. Dr. Roebers. We thank Prof. Dr. Roebers and her working group for providing the image material.

relevant information. Only children who successfully completed at least five of seven practice items were given the test items.

Task 2 – Flanker *focus outside*:

The task consisted of three practice items and 16 test items. In contrast to the first task, the children were instructed to focus on the outer fish (rule change to measure their cognitive flexibility) and press the corresponding button. Here, the differences (mistakes, response time) between the congruent and incongruent trials as well as the potential differences to Task 1 indicate how well the children were able to control their reactions. Task 2 was only administered to children who had already successfully completed the first or second practice phases of Task 1.

Task 3 – Control *reaction time*:

The task to control the basic reaction time of the children consisted also of three practice items and 16 test items. In this task, the children were instructed to press a button (regardless of the direction) as soon as possible when a fish appeared on the screen in order to measure the children's basic reaction speed. The items from the reaction time task were administered to all children.

The following variables are included in the Scientific Use File: the correctness of the answers (Tasks 1, 2) and the children's response times (Tasks 1-3); the median of the response times (a) for all correct test items, (b) separated for congruent and incongruent items as well as (c) the percentage of correct answers in the test phases of Tasks 1 and 2.

References

Bauer, P. J., & Zelazo, P. D. (2014). The National Institutes of Health Toolbox for the Assessment of Neurological and Behavioral Function: A Tool for Developmental Science. *Child Development Perspectives, 8*(3), 119–124. https://doi.org/10.1111/cdep.12080

Best, J. R., Miller, P. H., & Naglieri, J. A. (2011). Relations between Executive Function and Academic Achievement from Ages 5 to 17 in a Large, Representative National Sample. *Learning and Individual Differences, 21*(4), 327–336. https://doi.org/10.1016/j.lindif.2011.01.007

Blair, C., & Razza, R. P. (2007). Relating Effortful Control, Executive Function, and False Belief Understanding to Emerging Math and Literacy Ability in Kindergarten. *Child Development, 78*(2), 647–663. https://doi.org/10.1111/j.1467-8624.2007.01019.x

Carlson, S. M. (2005). Developmentally Sensitive Measures of Executive Function in Preschool Children. *Developmental Neuropsychology, 28*(2), 595–616. https://doi.org/10.1207/s15326942dn2802_3

Diamond, A. (1985). Development of the ability to use recall to guide action, as indicated by infants' performance on AB. *Child Development, 56*(4), 868–883. https://doi.org/10.1111/j.1467-8624.1985.tb00160.x

Hughes, C., & Ensor, R. (2007). Executive function and theory of mind: Predictive relations from ages 2 to 4. *Developmental Psychology, 43*(6), 1447–1459. https://doi.org/10.1037/0012-1649.43.6.1447

Latzman, R. D., Elkovitch, N., Young, J., & Clark, L. A. (2010). The contribution of executive functioning to academic achievement among male adolescents. *Journal of Clinical and Experimental Neuropsychology, 32*(5), 455–462. https://doi.org/10.1080/13803390903164363

Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H., . . . Caspi, A. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences, 108*(7), 2693–2698. https://doi.org/10.1073/pnas.1010076108

Rhodes, S. M., Booth, J. N., Palmer, L. E., Blythe, R. A., Delibegovic, M., & Wheate, N. J. (2016). Executive functions predict conceptual learning of science. *British Journal of Developmental Psychology, 34*(2), 261–275. https://doi.org/10.1111/bjdp.12129

Roebers, C. M., Röthlisberger, M., Neuenschwander, R., Cimeli, P., Michel, E., & Jäger, K. (2014). The relation between cognitive and motor performance and their relevance for children's transition to school: A latent variable approach. *Human Movement Science, 33*(1), 284–297. https://doi.org/10.1016/j.humov.2013.08.011

Rueda, M. R., Posner, M. I., & Rothbart, M. K. (2005). The development of executive attention: Contributions to the emergence of self-regulation. *Developmental Neuropsychology, 28*(2), 573–594. doi:10.1207/s15326942dn2802_2

Rueda, M. R., Rothbart, M. K., McCandliss, B. D., Saccomanno, L., & Posner, M. I. (2005). Training, maturation and genetic influences on the development of executive attention. *Proceedings of the National Academy of Sciences, 102*(41), 14931–14936. https://doi.org/10.1073/pnas.0506897102

Yeniad, N., Malda, M., Mesman, J., van Ijzendoorn, M. H., & Pieper, S. (2013). Shifting ability predicts math and reading performance in children: A meta-analytical study. *Learning and Individual Differences, 23*(1), 1–9. https://doi.org/10.1016/j.lindif.2012.10.004

Zelazo, P. D., & Müller, U. (2002). Executive Function in Typical and Atypical Development. In U. Goswami (Ed.), *Blackwell Handbook of Childhood Cognitive Development* (pp. 445-469). Malden, USA: Blackwell Publishing. https://doi.org/10.1002/9780470996652.ch20

Zelazo, P. D., Frye, D., & Rapus, T. (1996). An age-related dissociation between knowing rules and using them. *Cognitive Development, 11*(1), 37–63. https://doi.org/10.1016/S0885-2014(96)90027-1

Mathematical competence in elementary and primary education

In the National Education Panel Study, the construct of *mathematical competence* is based on the idea of *mathematical literacy* as defined, for example, by PISA. Thus, the construct describes "[…] an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded mathematical judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen" (OECD, 2003, p.

24). Regarding younger children, this idea refers to their competence in handling mathematical problems in *age-specific contexts.*

Accordingly, mathematical competence in the NEPS is operationalized by items assessing more than pure mathematical knowledge; instead, solving the items requires children to recognize and flexibly apply mathematics in realistic, mainly extra-mathematical situations.

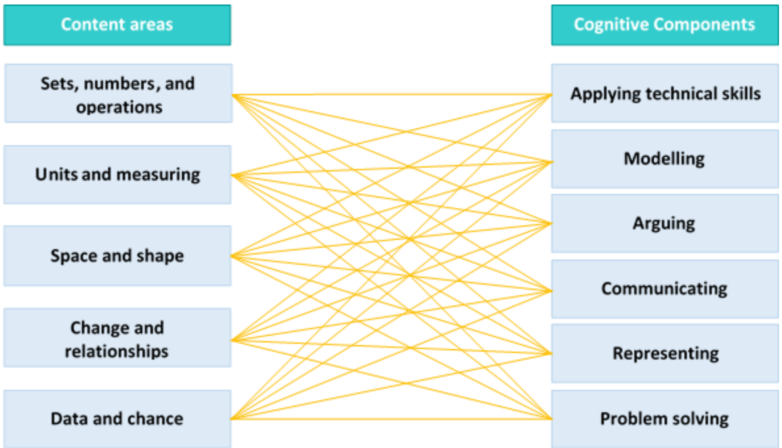

Fig. 1: Framework of mathematical competence in the NEPS for elementary and primary education

The NEPS framework of mathematical competence distinguishes between content-related and process-related components (cf. Fig. 1). Based on the German National Mathematics Education Standards for primary education, five content-related components are distinguished which are adapted for the NEPS as follows (KMK, 2004).

- **Sets, numbers, and operations** includes understanding numbers and their relations as well as contextualized calculations.
  Examples from *elementary and primary education*: comparisons of sets, counting (ordinal/cardinal aspects of numbers), simple operations (e.g., addition)
- **Units and measuring** comprises all kinds of quantification when numbers are used to organize and describe situations.
  Examples from *elementary and primary education*: comparisons of sets, knowledge and use of units, simple fractions in connection with units, length comparisons
- **Space and shape** includes all types of planar and spatial configurations, shapes or patterns.
  Examples from *elementary and primary education*: recognition of geometric shapes, simple properties of shapes, perspective
- **Change and relationships** includes all kinds of (functional) relationships and patterns.
  Examples from *elementary and primary education*: recognition and continuation of patterns, relationships among numbers, proportionality

For secondary and adult education, the content-related components "Sets, numbers, and operations" and "Units and measuring" are considered under the term "Quantity".
The cognitive components of mathematical thinking processes are distinguished as follows:

- **Data and chance** comprises all situations involving statistical data or chance.
  Examples from *elementary education*: intuitive assessment of probabilities, collecting and

structuring of data

The cognitive components of mathematical thinking processes are distinguished as follows:

- **Applying technical skills** includes the use of known algorithms and memory of mathematical knowledge or calculation methods.
- **Modelling** includes representation in a situation model and mathematical model as well as interpretation and validation of results based on real-life situations.
- **Arguing** includes the assessment of explanations and proofs, but also the development of own explanations or proofs.
- **Communicating** requires communication on mathematical contents and includes, among other things, the correct and adequate use of technical mathematical terms.
- **Representing** comprises the use and interpretation of mathematical representations such as tables, charts or graphs.
- **Problem solving** takes place when there is no obvious approach and, therefore, it includes systematic testing, generalization or examination of special cases.

The test items used in the NEPS refer to one content area which is mainly addressed by the item, but may contain several cognitive components (further description of the framework in Neumann et al., 2013). This differentiation renders the framework concept of mathematical competence in the NEPS compatible with both the PISA studies and the German National Mathematics Education Standards. Some literature also shows a high correlation between the NEPS, the PISA studies and German Federal States' comparisons from the Institute of Educational Quality Improvement (IQB): $r = .89$ for NEPS-PISA and $r = .91$ for NEPS-IQB (van den Ham, 2016).

References

KMK (resolutions of the Conference of Ministers of Education) (2004) Bildungsstandards im Fach Mathematik für den Primarbereich. Resolution of 15.10.2004. Munich, Germany: Luchterhand.

Neumann, I., Duchhardt, C., Grüßing, M., Heinze, A., Knopp, E., & Ehmke, T. (2013). Modeling and assessing mathematical competence over the lifespan. *Journal for Educational Research Online, 5(2),* 80–109. Retrieved http://journal-for-educational-research-online.com/index.php/jero/article/view/362.

Organisation for Economic Co-Operation and Development [OECD] (2003). The PISA 2003 assessment framework – mathematics, reading, science and problem solving knowledge and skills. Paris, France: OECD.

Van den Ham, A.-K. (2016). *Ein Validitätsargument für den Mathematiktest der National Educational Panel Study für die neunte Klassenstufe.* Unpublished doctoral dissertation, Leuphana University Lüneburg, Lüneburg, Germany.