NEPS
National Educational Panel Study

Research Data

Information on Competence Testing

NEPS Starting Cohort 1 — Newborns

Education From the Very Beginning

Wave 7: 6 years

LEIBNIZ INSTITUTE FOR
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Test information				
Test information	Six-year-old children were tested individually in their homes in the presence of the anchor person and the interviewer.			
Test sequence	The three competence measures were administered in the following sequence: 1. Basic cognitive skills (nonverbal) 2. Digit span: phonological working memory 3. Mathematical competence The children either used the tablet to solve the tasks on their own (Basic cognitive skills) or gave answers verbally (Digit span: phonological working memory). In the mathematical competence test, the interviewers documented the children's verbal answers; in some tasks, the children interacted directly with the tablet.			
Test duration (excluding setup)	approx. 35 minutes			
Information about the administered competence measures				
Construct	**Number of items**	**Duration (approx.)**	**Mode of administration**	**Next assessment**
Basic cognitive skills (nonverbal)				
Perceptual speed	42	90 seconds	visual stimuli presented on a tablet	Wave 11 (2022)
Reasoning	12	6 minutes	visual stimuli presented on a tablet	Wave 10 (2021)
Digit span: phonological working memory	19 tasks (max.), with a stopping rule	5 minutes	oral reply; a tablet was used for data entry	-
Mathematical competence	25 tasks	20 minutes	visual stimuli presented on a tablet; additional physical objects	Wave 9 (2020)

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.

Basic cognitive skills (nonverbal) – perceptual speed and reasoning

In the NEPS, basic cognitive skills are measured based on the differentiation between “cognitive mechanics” and “cognitive pragmatics” in accordance with Baltes, Staudinger, and Lindenberger (1999). While the former is measured using task contents with an approach that is as education-independent, new and domain-unspecific as possible, the tasks for measuring cognitive pragmatics are based on acquired skills and knowledge (Ackerman, 1987). Consequently, some of the domain-specific performance tests used within the framework of the NEPS may serve as indicators of pragmatics.

In contrast to this, the tests of basic cognitive skills aim at assessing individual differences in fluid cognitive abilities. While these abilities are subject to age-related changes, in comparison to education- and knowledge-related competences they have been proven to be less dependent on culture, experience and language. In this context, these tests provide an individual basis and a fundamental differentiating function for the acquisition of education-dependent competences.

Among the facets of cognitive mechanics, two common marker variables stand out: **perceptual speed** and **reasoning**.

Perceptual speed reflects the basal speed of information processing (*“speed“*). In the NEPS, this is measured using the **Picture Symbol Test (NEPS-BZT)** which is based on an improved version of the Digit-Symbol Test (DST) from the tests of the Wechsler family by Lang, Weiss, Stocker, and von Rosenbladt (2007). Analogously to this improved version, the NEPS-BZT requires the test person to enter the correct figures for the preset symbols according to an answer key.

Reasoning serves as a key marker of mental performance (Baltes et al., 1999). The **NEPS reasoning test (NEPS-MAT)** is designed as a matrices test, in line with the tradition of typical reasoning tests. Each item of the matrices test consists of several horizontally and vertically arranged fields in which different geometrical elements are shown – with only one field remaining free. The test person has to deduce the logical rules on which the pattern of the geometrical elements is based in order to be able to select the correct element for the free field from the solutions provided.

Both tests were designed in such a way that they can be effectively used without requiring changes to the item sets across as many age groups as possible and relatively independently from the subjects’ mother tongue. The tests were administered as both a paper-and-pencil and computer-based assessment. The computer-based assessment was administered for the first time in Starting Cohort 1, Wave 7.

The results of both tests provide an estimator of basic cognitive skills which, however, is not directly comparable to the overall result of a traditional intelligence test (IQ). It can be used to control for differential initial capacities in the competence acquisition process.

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Digit span – phonological working memory

The short-term memory or working memory is regarded as the bottleneck of information processing because it has a limited capacity. On the one hand, people can store an almost unlimited amount of information over the long term; on the other hand, their ability to immediately reproduce unrelated information (e.g., a telephone number) after hearing it once is limited. Short-term or working memory performance (functional capacity) differs interindividually and generally increases during childhood into adolescence (for a brief overview, see Weinert, 2010).

In the National Educational Panel Study, the construct "digit span" is based on the theoretical framework of the working memory model, for example, by Baddeley and Hitch (1974). The performance in so-called span tasks is taken as an indicator of the phonological working memory's capacity (Baddeley, 1992). In span tasks, sequences of numbers (or digits) are presented in auditory form, and the test person is instructed to reproduce them in the same order (i.e., "digit span"). Span tasks usually present digit spans of increasing length until the child cannot reproduce them correctly anymore; the result is the longest digit span the child is able to reproduce immediately and correctly after hearing it once (Baddeley, Gathercole, & Papagno, 1998). The short-term storage and immediate reproduction of auditory information is associated with the phonological loop, which is a passive subsystem in the working memory model (Baddeley & Hitch, 1974). Due to the fast presentation rate of the digit spans, differences in the usage of memory strategies are minimized. Therefore, the individual performance can be interpreted as an indicator for the capacity of the respective person's phonological working memory. The reproduction of the digit span is not only influenced by the structural capacity of the phonological loop but also by the speed of articulation and item identification, which in turn is associated with prior knowledge aspects, such as linguistic knowledge.

The individual capacity of the phonological short-term or working memory has been shown to be predictive of the development of linguistic skills, in particular of the acquisition of vocabulary (for an overview, see Baddeley, Gathercole, & Papagno, 1998; Gathercole & Baddeley, 1993; Weinert, 2010) and of the acquisition of reading skills (e.g., Berendes, Weinert, Zimmermann, & Artelt, 2013; Gathercole & Baddeley, 1993). In addition, a study by Krajewski and Schneider (2009) found an association between preschool phonological loop capacity and mathematical development in school.

In Starting Cohort 1 of the NEPS, the digit span task is based on the German version of the "Kaufman Assessment Battery for Children" (K-ABC; Melchers & Preuß, 2009). The task tests the ability to immediately reproduce a verbally presented digit span in the correct order (numerical memory). Digits between 1 and 10 are used, except for the multi-syllabic digit 7 (cf. Melchers & Preuß, 2009). The task and the auditory cues are presented in a standardized and age-appropriate way on a tablet PC; the instructional language is German. The task of the children is to immediately reproduce the respective digit span in the presented order.

The task consists of a practice phase and subsequent learning and test items. The practice phase contains one item which is repeated if the answer is incorrect or missing to ensure that the child has understood the instructions; the practice phase is not included in the total score. The phase is followed by seven sets, each consisting of two to three items. After the practice phase, Set 2 is administered; if all items of this set are missing or incorrect, Set 1 is administered and the test is finished for these children. For all other children, Set 3 is administered after Set 2. The first two items of Set 2 are learning items. This means that the children receive feedback on whether their answer is correct from the tablet PC, and the item is repeated if necessary. The learning items are only included in the total score if they are reproduced correctly at the first attempt. Set 1 features items with two digits and the number of digits increases by one per set; hence, Set 7 features items with eight digits. The practice items are not relevant for the termination of the test; after the practice phase, the test ends if all items of a respective set have been answered incorrectly. The theoretically achievable maximum score is 19 (17 test items and two learning items); each correct item is scored with one point.

In the Scientific Use File[2], the following variables are published: the number of administered practice items; the correctness of each learning and test item; the total score of all correctly solved learning and test items; the longest digit span achieved (at least one correct answer); a variable that displays the set in which the test was terminated. For the learning items, only the child's first attempt was scored.

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[2] Note: The described data refer to SUF version SC1:7.0.0.

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.

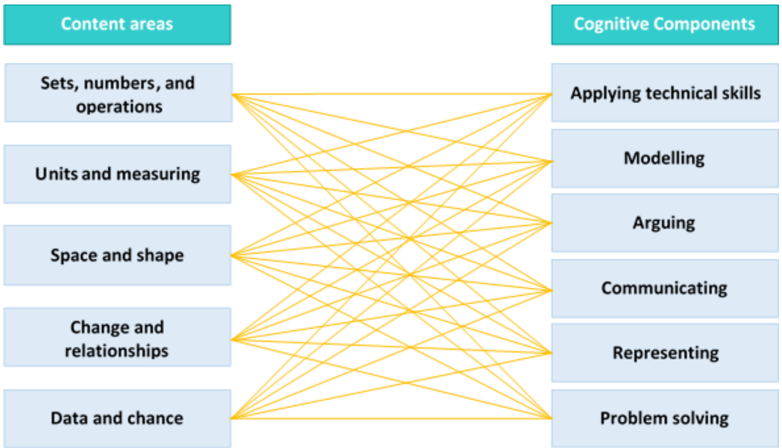

Fig. 1: Framework of mathematical competence in the NEPS for elementary and primary education

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 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 in real-life situations.
- **Arguing** includes assessment of explanations and proofs, but also 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, includes systematic testing, generalization or examination of special cases.

The test items used in the NEPS refer to one content area that is mainly addressed by the item, but may well 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 the 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).

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