NEPS *SURVEY PAPERS*

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VISUAL HABITUATION - DISHABITUATION TASKS IN NEPS STARTING COHORT 1: APPROACHES TO INTERPRETING THE DATA

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Visual Habituation-Dishabituation Tasks in NEPS Starting Cohort 1: Approaches to Interpreting the Data

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Abstract

Research suggests a certain degree of interindividual stability and continuity in cognitive development. Studying basic cognitive abilities in young children is crucial for understanding the development of later abilities, skills, and competencies. One central behavioral method for studying early cognition are habituation-dishabituation tasks. In habituation-dishabituation tasks, children's visual attention towards different stimuli are examined. Typically, a sequence of identical or similar stimuli are presented in a habituation phase, whereas the subsequent dishabituation phase features a novel and divergent stimulus. A broad consensus is that such behavioral measures reflect early cognitive abilities, namely stimulus encoding, remembering, and discrimination. As one of few large-scale studies, the Newborn Cohort of the German National Educational Panel Study (NEPS SC1) used habituation-dishabituation tasks to assess early cognitive abilities in the first two survey waves, namely when the children were on average 7 months and 17 months. This survey paper provides an overview on the theoretical and empirical backgrounds of these tasks. Further, a detailed technical report on the stimulus material and testing procedure is given. In addition, there is an overview on what kind of information is available for the scientific community in the Scientific Use File. In the main section, several approaches to the data are presented as a means to estimate children's habituation and dishabituation and, consequently, generate indicators of early cognitive abilities. This includes a number of discrete index measures that are typically used in the literature as well as examples of a data reduction procedure that has seen less coverage in infant research. The index measures are contrasted and their usage with regard to NEPS SC1 is discussed. Finally, we provide information on, among others, task disturbances, missing data, and child characteristics that are useful for data selection and interpretation.

Keywords

Habituation, infants, cognitive development

Table of contents

1. Introduction and theoretical background

From a lifespan perspective, it is necessary to study the development of cognitive abilities from infancy. To understand the origins of later competencies and achievements in educational settings, young children's cognitive functioning needs to be examined, especially in the context of other interindividual differences regarding structural and environmental factors (e.g., socioeconomic background, parenting behavior, and educational institutions). Fantz' (1964) seminal study on infant visual habituation marked the beginning of modern investigations on the cognitive development of young children and highlighted that even with preverbal infants, habituation-dishabituation tasks can give insight into cognitive functioning at an early age (Colombo & Mitchell, 2009). The central observation was that by presenting children with a series of visual stimuli, their behavioral response, for example fixation or looking time, could be measured. The underlying concept is that children distribute attention to the stimulus material, which is associated with distinct behavioral patterns. Habituation and the conceptually related process of familiarization (Aslin, 2007) refer to the phenomenon of decreasing attention throughout a sequence of either identical or similar stimuli, while dishabituation covers the subsequent mechanism of attention recovery when a novel stimulus is shown. Habituation and dishabituation are generally thought to reflect aspects of basic cognition such as attention, categorization, or information processing (Colombo & Mitchell, 2009). Since the 1960s, research has used this basic paradigm in numerous variations by manipulating the stimulus material, presentation time, or the presentation mode (Thompson, 2009). Often, habituation-dishabituation tasks are used to study early precursor abilities of later cognitive skills or competencies (Colombo & Mitchell, 2009).

This section provides an introduction to the theoretical background of habituation-dishabituation tasks (**1.1 Theoretical background on infant habituation**) as well as basic information on how habituation-dishabituation tasks are used to predict later skills and competencies (**1.2 Predicting cognitive abilities with habituation-dishabituation tasks**). Finally, the use of habituation-dishabituation tasks in large-scale studies is discussed, which is linked with the question why they are a relevant method for studying early cognition abilities (**1.3 Uses in large-scale studies**).

1.1 Theoretical background on infant habituation

Historically, there have been several approaches to explaining the phenomena of habituation and dishabituation. Early theories essentially hold habituation as a sign of fatigue and dishabituation as perceptual sensitization. Such models theorized that habituation is either predominately a physiological process of local retinal adaptation (Bronson, 1974) or a process of selective cortical adaptation (Dannemiller & Banks, 1982). However, because processes of habituation and dishabituation occur independent of the eye (Slater et al., 1983) and in tasks with delayed stimulus presentation (Slater & Morison, 1985), purely perceptual frameworks cannot explain the phenomena adequately.

In contrast, cognitive theories hold habituation and dishabituation as indicators of information processing in infants. The most popular cognitive model is Sokolov's (1990) comparator model, in which habituation reflects the formation of a neuronal representation of the stimulus (i.e., stimulus encoding), whereas dishabituation reflects stimulus discrimination (Kavšek, 2013). The decrement in looking times during the habituation phase is, hereby, the result of an activated inhibitory system in the hippocampus that increasingly suppresses the orientation response. In accordance, dishabituation is a renewed orientation response to a novel stimulus due to a lack of inhibition because the novel stimulus does not match the previously formed mental representation. Sokolov's conceptualization remains one of the most relevant theoretical frameworks to understand the processes of habituation and dishabituation in infancy (Kavšek, 2013; Sicard-Cras et al., 2022). Still, it should be noted that while attention decrement is generally interpreted as an indicator of information processing (Colombo & Mitchell, 2009), many internal and external factors may contribute to any observable behavior in young children (e.g., familiarization or fatigue; Houston-Price & Nakai, 2004; Slaughter & Suddendorf, 2007).

Although many studies on infant cognition use habituation-dishabituation tasks, there are essential differences in stimulus material, presentation time, and presentation mode. Generally, there are infant-controlled and fixed-trial designs. In the former, the transition from the habituation to the dishabituation phase is administered adaptively if the child showed a pre-defined decrement in looking time; in the latter, the presentation time for all stimuli as well as for the intertrial interval is the same (Oakes, 2010). Stimulus material in the dishabituation phase may be presented alone or paired with a distracting stimulus, depending on the research design. In fixed-trial designs, children's reaction indicates attention recovery, in infant-controlled designs, novelty preference is assessed (Colombo & Mitchell, 2009). For most task types, stimulus material can be manipulated in a number of ways (e.g., identical stimuli vs. categorical stimuli) and modes (e.g., visual, auditory, tactile). Overall, there have been numerous approaches at operationalizing attention decrement and attention recovery, depending on the research question and data availability, and the present report only presents selected measures (**4. Approaches to interpreting the data**).

1.2 Assessing early cognitive abilities with habituation-dishabituation tasks

Empirically, visual habituation-dishabituation tasks are used, among others, to study children's perception (Arterberry & Kellman, 2016), categorization skills (Quinn & Eimas, 1996), memory capacity (McCall & Carriger, 1993), understanding of physical (Baillargeon, 2008) and mathematical processes (Cantrell & Smith, 2013), statistical learning (Bulf et al., 2011), and theory of mind (Onishi & Baillargeon, 2005). They are not only used for testing theoretical assumptions of early cognition but also to study typical and atypical cognitive development and early predictors of later cognitive skills and competencies. Because of a certain degree of continuity and stability in information processing in childhood (Bornstein, 1985; Jensen, 1993; Kail, 1991), habituation and dishabituation measures can be used as early predictors of interindividual cognitive differences (e.g., Davis & Anderson, 2010). In this context, continuity refers to the assumption that individual sources of variation in early abilities and skills explain variation at later time points, whereas stability refers to children's relative rank order in their performance on cognitive tasks over time when compared to others (Bjorklund & Causey, 2018).

Habituation efficiency and attention recovery, indicating fast stimulus encoding and good discrimination abilities, are seen as a foundation of general cognitive development (Bornstein et al., 2006; McCall & Carriger, 1993). Habituation measures are reasoned to be associated with speed of information processing or fluid intelligence, while dishabituation measures are associated with recognition memory or memory capacity (Rose et al., 2004; Rose et al., 2012). Because children need to compare each stimulus with the previous ones, processes of repeated memory updating are activated that are essential for working memory (Ropeter & Pauen, 2013). Thus, habituation and dishabituation measures have been used to predict later general cognitive functioning (McCall & Carriger, 1993), receptive and productive language skills (Tamis-LeMonda & Bornstein, 1989; Dixon & Smith, 2008), and school achievement (Bornstein et al., 2013; Colombo et al., 2004). The predictive effects were found to be robust, even after controlling for the children's family background, like maternal education or socio-economic status (Bornstein et al., 2006). Meta-analyses (Kavšek, 2004b; McCall, 1994) have shown medium-sized predictive effects of early information processing as measured with habituation-dishabituation tasks for later intellectual functioning (habituation measures: r=.45; dishabituation measures: r=.39; see also Domsch et al., 2009).

Regarding the predictive effects of habituation and dishabituation measures for various aspects of cognition, studies showed that attention decrement (i.e., stimulus encoding) and attention recovery (i.e., stimulus discrimination) are positively associated with early cognitive abilities (Bornstein & Sigman, 1986; McCall & Carriger, 1993; Rose et al., 2012). More specifically, habituation in three-month old children positively predicts IQ scores (e.g., Griffiths Mental Development Scales; Griffiths, 1984) four years later (Bornstein et al., 2006; Laucht et al., 1994), although effects are small (coefficients of up to r=.21). Still, arguing for developmental cascades, Bornstein and colleagues (2013) found that habituation efficiency had a distinct positive, albeit indirect, effect on school achievement ten years later (r=.06). Several authors argue that habituation-dishabituation tasks are more useful than standard developmental tests for assessing early cognitive abilities in infants and predicting later skills and competencies (McCall, 1994; Teubert et al., 2011), especially in longitudinal designs.

When studying such predictive effects, habituation-dishabituation tasks may tap into either domain-general or domain-specific precursor abilities. While there is considerable debate about the nature and relation of underlying domain-general and domain-specific mechanisms of cognition (for a discussion, see Rakison & Yermolayeva, 2011), many researchers agree that children's developmental learning process necessarily involves domain-general and domain-specific abilities (Bjorklund & Causey, 2018). Habituation-dishabituation tasks indicate early learning, which contributes to how children acquire new content knowledge and develop competencies. In this sense, habituation-dishabituation can be used to assess cognitive precursor abilities of later skills and competencies in various domains of knowledge, such as mathematics or language (National Research Council, 2015).

1.3 Uses in large-scale studies

Cognitive abilities at an early age are frequently assessed in large-scale studies drawing on newborn cohorts (Hachul et al., 2019). When opting for behavioral observations, most studies use the Bayley Scales of Infant Development (Bayley, 2006) or the extended Infant Scales of the Griffiths Mental Developmental Scales (Griffiths, 1970; Luiz et al., 2001) (see Hachul et al., 2019). However, in large-scale assessments, the administration of such standardized developmental tests can be relatively error-prone. In addition, such tests in the first two years of life have poor predictive validity for later cognitive functioning (Aylward, 2013; Krogh & Væver, 2019), probably due to the focus on potentially unstable sensorimotor measures (Dunst & Rheingrover, 1981). Thus, in the Newborn Cohort of the German National Educational Panel Study (NEPS SC1) habituation-dishabituation tasks were implemented for assessing basic cognitive abilities in addition to a short measure of sensorimotor development

(Weinert et al., 2016). For studying cognitive development in children, large-scale studies are important because they are typically more heterogeneous than laboratory studies (Oakes, 2017). Moreover, small laboratory studies might lead to an overestimation of actual effects at the population level (Maxwell, 2004), which is why large-scale studies need to replicate and verify existing findings (Oakes, 2017).

Small laboratory studies often have homogeneous samples because of convenience sampling, resulting in an unwanted focus on infants from a middle-class socioeconomic background (Fernald, 2010). Relying on such samples could potentially lead to biased findings on infant cognitive development (Henrich et al., 2010) because socioeconomic background is associated with interindividual differences in cognitive stimulation from early on (Attig & Weinert, 2018). Likewise, Bronfenbrenner's bioecological model of human development (Bronfenbrenner & Morris, 2006) stresses the importance of the family on the microsystem level, especially the effect of the social class (e.g., parental income and education). Empirically, it could be shown that social disparities in the cognitive development of infants can be found as early as 9 months (Halle et al., 2009). Few studies have investigated effects of socioeconomic background on early cognitive abilities using habituation-dishabituation tasks, probably because of the selective samples that usually participate in laboratory studies (Oakes, 2017). To conclude, there are associations of young children's socioeconomic backgrounds and their cognitive development, which is why large-scale studies with heterogeneous samples are important.

To the knowledge of the authors, apart from NEPS SC1, there have been only two previous large-scale studies in which habituation-dishabituation tasks were used: The Mannheim Study of Children at Risk (MARS) and the Avon Longitudinal Study of Parents and Children (ALSPAC). MARS was a German prospective longitudinal study of psychosocial risk factors on child development that started data collection in 1986 (Esser & Schmidt, 2017; Laucht et al., 1994; Laucht et al., 2000). ALSPAC was a British population-based study that started data collection in 1991. In ALSPAC, the tasks were administered in an infant-controlled design at 4 months in the Child in Focus subsample (about 10% of the cohort; The ALSPAC Study Team, 2019). Measures of visual attention and visual recognition memory were included as predictors of later cognitive development, as an outcome measure of prenatal maternal behavior, and as a control variable for general child development (Moulton et al., 2020). Methodologically, analyses of the large-scale data have shown that non-completion of the habituation task, namely because the children were too restless, tired or distressed, was not at random, highlighting the potential bias in existing data and warning against generalizations of the findings (Bell et al., 1998; Bell et al., 2002). With regard to the validity of the measures as indicators of early cognitive functioning, only few analyses have included the tasks (Bornstein et al., 2006; Bornstein et al., 2013).

The aim of the present survey paper was to provide an overview of all habituation-dishabituation tasks used in NEPS SC1. In the next sections, information on the stimulus material, testing procedure, coding procedure (**2. Stimulus material and task procedure**), and sample are given (**3. Information on available data**). We selected two general approaches to interpreting the children's habituation and dishabituation (**4. Approaches to interpreting the data**): Index measures for interindividual comparisons and more advanced data reduction techniques. As we were interested in interindividual differences, we also examined age-related differences. In addition, information on data selection is given and methodological caveats when using NEPS SC1 are discussed (**5. Data selection**). Finally, we summarized central findings from our calculations (**6. Summary and conclusion**). The stimulus material can be found in the appendix (**8. Appendix**).

2. Stimulus material and task procedure

This section provides a technical report and overview of the habituation-dishabituation tasks used in NEPS SC1. The aim of this survey paper is to inform users of approaches to the available data and highlight potential ways to analyze them. As habituation-dishabituation tasks tap into early cognitive abilities, the data may be used to investigate the development of cognition, examine the predictive validity of measures drawn from the tasks for later skills and competencies, or control for early interindividual differences in cognition (Weinert et al., 2016).

At Wave 1 (children on average 7 months) and Wave 2 (children on average 17 months), domain-general and domain-specific habituation-dishabituation tasks were conducted to assess children's early cognitive abilities. In the context of NEPS, the terms domain-general and domain-specific refer to precursor abilities for later skills development. Similarly, cognitive abilities refer to a global capacity of applying various aspects of mental processes for learning and knowledge acquisition (VanLehn, 1996). Thus, the habituation-dishabituation tasks in NEPS SC1 were conceptualized to assess early learning in more general and more specific domains of cognition (e.g., mathematics and language).

Overall, there were four different tasks: Two domain-general categorization tasks (Wave 1: Task A and Task B; Wave 2: Task C; Task B and Task C used the same stimulus material); a numerical task (Wave 2: Task D); and a word-learning task with categorical stimulus material (Wave 2: Task E). The domain-general categorization tasks featured categorical stimulus material during the habituation phase with an out-of-category exemplar during the dishabituation phase. The level of complexity differed between the tasks and the more complex task was also administered at Wave 2 for comparing the children's habituation and dishabituation over time. The numerical task featured varying proportions of magnitude that were reversed in the dishabituation phase. Finally, the word-learning task featured categorical stimulus material during the habituation phase that was presented with a pseudoword.

For all tasks, a fixed-control procedure without task or stimulus randomization was chosen because a reliable on-line coding of the children's looking behavior with trained interviewers in the children's households with a limited experimental setup was not possible. As suggested by Werner and Perlmutter (1979), fixed-trial designs can be useful for samples with a broad age range because they accommodate individual differences in encoding time. The focus in NEPS SC1 was on interpreting interindividual differences, which fixed-trial designs typically allow for (Slater et al., 1984; Thomas & Gilmore, 2004). In addition, an attention control phase with completely different pictures was included for all tasks to control for possible effects of fatigue or distractions in the children's homes.

It is theoretically expected that habituation-dishabituation tasks assess information processing or early learning, which is indicated by attention decrement (familiarity effect) during the habituation phase and attention recovery (novelty effect) during the dishabituation phase (Figure 1). Thus, the domain-general tasks were expected to assess early categorical information processing, which should be predictive of later general intellectual functioning.

The numerical task was hypothesized to tap into children's early numerical understanding or quantitative abilities, which should be a precursor of later mathematical skills. Finally, the word-learning task tested children's early word learning, which should be an important precursor of later vocabulary development.

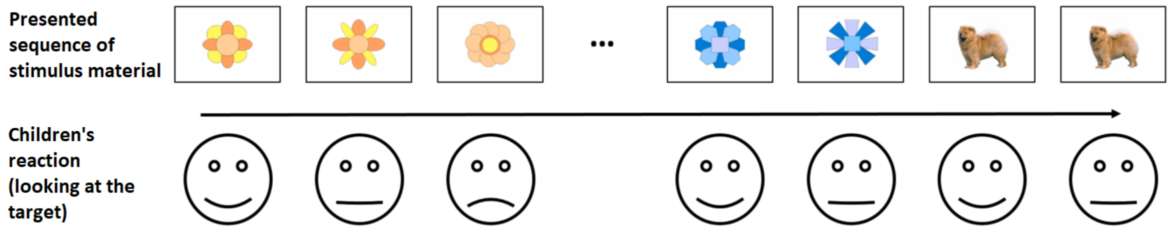

Figure 1. Schematic illustration of the procedure of the habituation-dishabituation tasks.

2.1 Experimental setup

NEPS SC1 (NEPS Network, 2021)[1] collected data nation-wide between August 2012 and March 2013 (Wave 1) and between July 2013 and December 2013 (Wave 2). Both the parental interviews (Wave 1) and the child observations were conducted in the households (direct behavioral measures). On average, a home visit lasted about 95 minutes in Wave 1 (i.e., interview and observation of the child) and 60 minutes in Wave 2 (i.e., a preliminary telephone interview of the full sample and child observation of half of the sample at a later point) (Weinert et al., 2016). Visual habituation-dishabituation tasks as direct behavioral measures were administered at both waves. Interviewers who had a professional background in large-scale interviews were trained regarding psychological testing to administer the tasks. To ensure a standardized procedure in the households of the participating families, the experimental setup and task sequence were clearly defined, and extensive training courses for the interviewers were provided.

The children sat on the lap of their parent, which was in the most cases the biological mother (Wave 1: 98.19%; Wave 2: 99.02%). The experimental setup, consisting of a notebook (model: Lenovo T60) for presenting the stimulus material and a video camera (model: AIPTEK AHD Z700) for recording the children's behavior, was arranged on a nearby table (height: 65-85 cm). The interviewers should clear away any distracting objects and arrange the whole setup so as no light reflections would impair the children's sight.

The stimulus material was presented as a video sequence on the notebook, with the volume set to maximum. The notebook was on a cardboard box and both the setup and the screen were adjusted to the infants' ideal field of vision. The cardboard box was 10 cm from the edge of the table, with the screen being 1 m away from the infant's ear. One foldable visual cover was placed over the notebook's keyboard, while another was used to mask the camera and

[1] This paper uses data from the National Educational Panel Study (NEPS; see Blossfeld & Roßbach, 2019). The NEPS is carried out by the Leibniz Institute for Educational Trajectories (LIfBi, Germany) in cooperation with a nationwide network.

the area behind the notebook. The camera lens protruded the visual cover to record the children's behavior from a central angle (Figure 2).

The parent was instructed to sit as quietly as possible and not distract the child in any way (e.g., verbal or non-verbal reactions to the stimulus material). However, the parent was not blindfolded. During the task, the interviewer stood behind the parent, away from the child's field of vision. Other people (e.g., partners) or pets were not allowed in the same room, with the only exceptions being young siblings in cases where they could not be taken care of in another room.

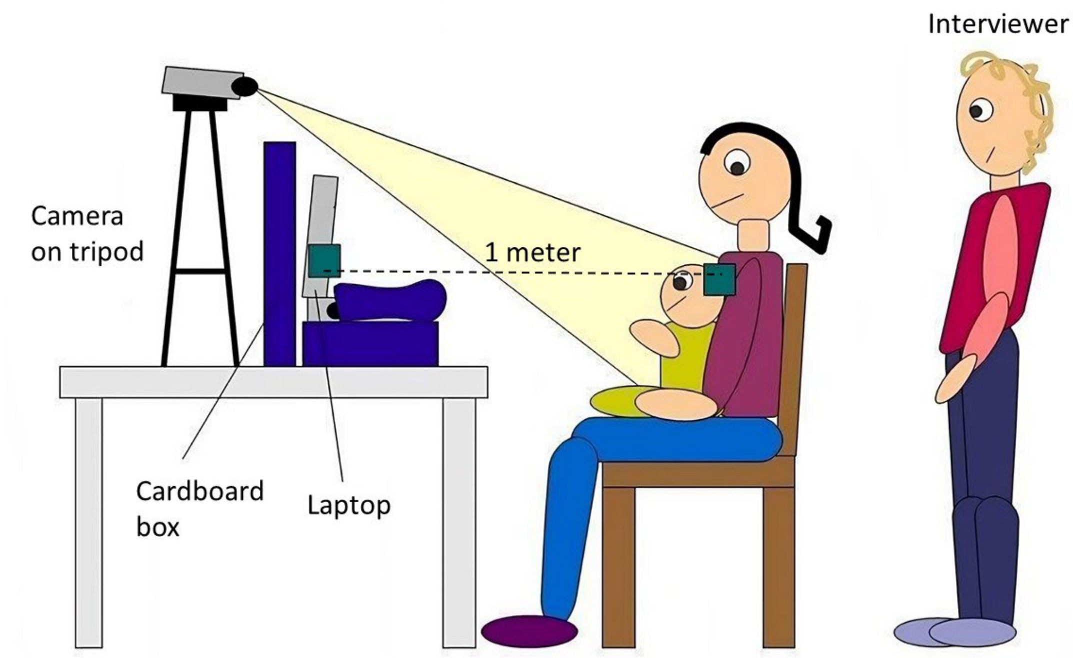

Figure 2. Schematic illustration of the task administration.

2.2 Task administration

As the habituation-dishabituation tasks were administered by interviewers who typically had no professional background in conducting experiments, a high degree of standardization and off-line coding were necessary, which is why a fixed-trial design was chosen. The interviewers were instructed to choose when to administer the habituation-dishabituation task during the parental interview. This way, fatigue effects could be avoided and the tasks could be assessed when the child was deemed alert, calm, and cooperative.

During the experimental setup, a blue dummy screen was shown. All tasks started the same way, with a countdown (i.e., numbers 3-1) and a subsequent eye-catcher (i.e., an animated penguin accompanied by a short three-note jingle). When the interviewer started the experiment, descending black numbers from 3-1 were shown on the blue screen (count in) (**8. Appendix: Stimulus material**). After that, the habituation phase started immediately.

2.3 Procedure at Wave 1

At Wave 1 (infants aged on average 7 months), all infants of the sample were asked to participate in a fixed sequence of two visual, domain-general habituation-dishabituation tasks testing categorization skills (Task A; Task B). Regarding the sequence of the stimulus material and the presentation time, the procedure was the same for all infants. In both tasks, the habituation phase was followed by a dishabituation phase and a subsequent attention control phase, respectively (**8. Appendix: Stimulus material**). The habituation phases featured a number of individually presented categorical stimuli. The dishabituation and attention control phases deviated to different extents from the respective habituation phase. The dishabituation phase featured images comparable to the previous habituation phase but deviant in form and color (i.e., out-of-category exemplars). Thus, this phase tested children's attention recovery and categorization. The attention control phase featured completely different pictures to check for effects of fatigue. All habituation trials were presented for 10 seconds and were accompanied by an audio cue (i.e., a three-note jingle) to attract the children's attention. The dishabituation and attention control trials were presented for 15 seconds, also accompanied by the audio cue; for reasons of comparability, only 10 seconds were coded and made publically available. Intertrial interval duration was 2 seconds, or 1 second between two trials of the dishabituation and attention control phases, respectively. There was a pause interval of 5 seconds between the tasks. The habituation phases featured nine trials, meaning nine individual pictures. Overall, administering both tasks lasted for about 6.5 minutes.

2.4 Procedure at Wave 2

At Wave 2 (toddlers aged on average 17 months), half of the original sample2 participated in a fixed sequence of visual habituation-dishabituation tasks: A domain-general task testing categorization skills (Task C), a domain-specific task testing numerical abilities (Task D), and a domain-specific task testing word learning (Task E). Regarding the sequence of the stimulus material and the presentation time, the procedure was the same for all children. In all tasks, the habituation phase was followed by a dishabituation phase and a subsequent attention control phase, respectively (8. Appendix: Stimulus material). The habituation phases featured a number of individually presented categorical stimuli. The dishabituation and attention control phases deviated to different extents from the respective habituation phase. The dishabituation phase featured images comparable to the previous habituation phase but deviant in form and color (i.e., out-of-category exemplars; Task C; Task E) or with a reversed proportion, respectively (Task D). Thus, this phase tested children's attention recovery and categorization (Task C), numerical abilities (Task D), or word learning (Task E). The attention control phase featured completely different pictures to check for effects of fatigue. All trials were presented for 10 seconds and were accompanied by an audio cue (i.e., a short three-note jingle) to attract the children's attention, except for Task E. Intertrial interval duration was always 2 seconds. There was a pause interval of 5 seconds between the tasks. The habituation phases featured nine trials (Task C; Task E), or four trials (Task D), respectively. Overall, administering all tasks lasted for about 7.5 minutes.

2.5 Stimulus material

Task A: The first task at Wave 1 featured categorical stimuli to test children's domain-general categorization skills. All trials were introduced by a short three-note jingle played once (400-300-500 Hz; 1.14 seconds). The habituation phase featured various curvilinear cartoon flowers

[2] By design, only half of the sample (random selection) was visited at home to participate in the habituation-dishabituation tasks. Beforehand, all families participated in a telephone interview when the children were on average 14 months old.

with an orange and yellow color scheme, while the dishabituation phase featured two different rectangular cartoon flowers with a blue color scheme. The attention control phase featured two identical photos of a dog. The stimulus material was adapted from previous validation studies (Pahnke, 2007)[3].

Task B: The second task at Wave 1 featured categorical stimuli to test children's domain-general categorization skills. All trials were introduced by a short three-note jingle played once (500-500-400 Hz; 1.14 seconds). The habituation phase featured various curvilinear cartoon bugs with symmetrical antennae, while the dishabituation phase featured two different rectangular cartoon bugs with asymmetrical antennae and a blue color scheme. The attention control phase featured two identical photos of a pineapple. The stimulus material was used and tested in previous studies at the chair of developmental psychology at the University of Bamberg, Germany (Zhang, 2007).

Task C: The first task at Wave 2 was nearly identical with Task B. The only difference to Task B was that in Task C the presentation time of the dishabituation trials was shorter (i.e., 10 seconds instead of 15 seconds). Administrating the same task at Wave 2 was deemed useful for analyzing the development of habituation and dishabituation.

Task D: The second task at Wave 2 featured number-related stimuli to test children's domain-specific understanding of non-symbolic magnitudes, which is also called numerical ability (Geary, 2000) or numeracy (Bynner & Parsons, 1997). All trials were introduced by a short three-note jingle played once (400-300-500 Hz; 1.14 seconds). An adapted version of Cooper's (1984) stimulus material was tested at the chair of developmental psychology at the University of Bamberg, Germany (Freund, 2012). A sequence of four pictures was presented in the habituation phase; cartoon sheep were always on the left side, whereas cartoon bears were always on the right side. In each presented habituation picture, the number of sheep outmatched the number of bears (≤ 4 per category). The first dishabituation stimulus reversed the ratio in favor of the bears and the second dishabituation picture had a balanced ratio. The attention control phase featured two identical photos of a flower. Thus, the task tested whether children would be surprised by the shift in magnitude at the transition to the dishabituation phase, and consequently show more attention to the novel stimulus.

Task E: The third task at Wave 2 featured categorical stimuli in combination with a pseudoword (Zhang, 2007). In the habituation phase, the visual stimuli were imaginary cartoon creatures that were made of a varying number of circular shapes. All had the same facial features (i.e., eyes, nose, and mouth). In the two trials of the dishabituation phase, the creatures consisted of rectangular shapes and dim colors. Because of the rectangular design, the facial features were markedly different from the previous trials. The attention control phase featured two identical pictures of a tree. With each visual stimulus, a pseudoword was played as a language-related stimulus. The pseudoword was played once per picture and was accompanied by an object identifier (i.e., "Ein Jalos"; 1.93 seconds). "Ein" is a German indefinite article and "Jalos" is a pseudoword referring to the creature (Waxman & Kosowski, 1990). The auditory stimulus was produced by an adult woman and did not vary, as variation is often thought to be distracting (Parmentier et al., 2011). Thus, the task can be considered a

[3] We would like to thank Prof. Dr. S. Pauen for her advice on the implementation of the paradigm.

word-learning task, as the pseudoword was presented in combination all stimuli (e.g., Stekmachowicz et al., 2004).

2.6 Coding procedure

The tasks were recorded in the households of the families on a video camera in 30 frames per second, at a resolution of 1280×720 pixel. The children's looking behavior was coded offline by trained independent raters blind to the stimulus material. For each frame, the children's looking behavior was categorized in "towards the target" or "away from the target". Blinking (i.e., events ≤ 8 frames) was coded as a continuous target fixation, if the child looked at the target stimulus before and after having blinked. In this manner, looking times were accumulated for each trial. While visual attention research uses more fine-grained definitions of fixation time (Hendry et al., 2019), in the context of NEPS SC1, the term refers to the global looking time on target. The coding software was Interact 9.6.1.170 (Mangold International, 2011; see Attig & Weinert, 2018; Weinert et al., 2017). Interrater reliability was tested on a subsample of 10% of all videos at each wave. Two independent raters coded randomly drawn videos and the collapsed rating agreement at Wave 1 (unadjusted level of agreement: 95%; κ=.92) and Wave 2 (unadjusted level of agreement: 96%; κ=.92) was high.

2.7 Household setting

As findings and field reports from comparable large-scale studies were limited and household settings in habituation research had seldom been compared to laboratory settings (Bornstein & Ludeman, 1989), prior to NEPS SC1, run-up tests were conducted to identify issues that could be a threat to standardization. Several aspects were identified that were also addressed in the training course of the interviewers, even if certain aspects could not be standardized.

Lighting: Uneven or unbalanced illumination in the room of observation could distract children and lead to unreliable video coding. The interviewers were trained in creating comparable lighting for each observation, but given the heterogeneity of the households, this aspect could not be completely standardized.

Furnishing: Tables and chairs of varying sizes and heights were expected in the households. Therefore, certain necessary features were defined (i.e., table height), while others were prohibited (e.g., the use of swivel chairs). It was expected that such basic furniture should not be a problem in most households.

Laptop setup: The tilt angle of the screen had to be adjusted by the interviewers in order that the children could see the stimulus presentation without any distractions (e.g., screen glare). Therefore, the interviewers should check the children's field of vision before starting the tasks.

Camera position: The interviewers were instructed to position the camera for recording the children's looking behavior at a preset height directly behind the laptop setup. Thus, the position was centered and the height of the camera was fixed, regardless of the differences in interior design of the households.

3. Information on available data

The following section provides information on all available data in the public Scientific Use File[4] (NEPS Network, 2021). Due to data curation other data releases might differ from the data set used for the present calculations, although no fundamental changes regarding the data of the habituation-dishabituation tasks are expected. In the following sections, the general sample is described, as not for all children valid looking times are available even though most parents gave consent in participating in the habituation-dishabituation tasks (**3.1 Data base information**). In addition, descriptive information on children's accumulated fixation times on target is provided (**3.2 Describing the data**). These fixation times provide the basis for the calculations in the latter section of this report.

3.1 Data base information

Overall, NEPS SC1 started with a sample size of N=3481 children at Wave 1. However, due to a lack of parental consent, sample attrition, study design, child-related reasons, and extraneous disturbances, the habituation-dishabituation tasks were not assessed or could not be correctly coded in all cases. Table 1 reports information on parental consent in participating in the habituation-dishabituation tasks, which was administered during the parental interview (Wave 1) or on a separate date after the parental telephone interview (Wave 2). At both waves, parental consent was high. At Wave 2, all parents were asked to participate in a telephone interview; however, only half of the sample was by design asked to participate in the habituation-dishabituation tasks (N=1510). Due to the large-scale sampling, children's age was broadly distributed: Wave 1 (M=7.00 months, SD=0.76, Min=5.15, Max=11.93), Wave 2 (M=17.05 months, SD=0.61, Min=15.77, Max=20.36).

Table 1

Parental Consent in Participating in the Habituation-Dishabituation Tasks

	Wave 1 (**full sample**)	**Wave 2** (**half sample per design**)
Informed consent	3129 (89.89%)	1484 (98.28%)
No consent	352 (10.11%)	26 (1.72%)

Note. Percentages refer to the total sample at Wave 1 (N=3481) and to the sample for which observational measures were planned at Wave 2 (N=1510), respectively.

Not all cases in which parents consented in participating in the habituation-dishabituation tasks could be realized. This dropout was due to child-related reasons, namely that the child was unfit to participate at the moment, or due to external reasons. At Wave 1, there were video recordings of N=2945 (94.12%) children, whereas at Wave 2, there were video recordings of N=1315 (88.61%). However, not all of these video recordings could be validly coded, for example, due to multiple and/or severe disturbances during the observation.

[4] The current version of the Scientific Use File (Release 9.1.0) only includes data on the first habituation-dishabituation task at Wave 1 (Task A) and Wave 2 (Task C), respectively. Data of all other tasks were coded and processed under another grant (Project ViVA at the University of Bamberg) and will be added in future data releases. "ViVA: Video-based Validity Analyses of Measures of Early Childhood Competencies and Home Learning Environment" – project funded by the German Research Foundation (DFG) within the priority programme 1646 (grant to Sabine Weinert; WE 1478/7-1; WE 1478/7-2). We thank Jan-David Freund for his contribution to the project and the coding.

Disturbances that occurred while the tasks were administered were typically not child-related (see also Table 22), but rather due to external factors (e.g., lighting condition, distracting noises, parental interference, interviewer error). Table 2 reports an overview of the codability of the videos; looking time data for cases with multiple and/or severe disturbances were not released in the Scientific Use File. In most tasks, a large percentage of the children participated with no external disturbances or distractions. Given the household setting with limited standardization, this was deemed adequate. Detailed information on the types of disturbances is reported in Table 22.

Table 2

Video Codability Rating of the Habituation-Dishabituation Tasks

	Not evaluable (multiple/severe disturbances)	**At least one problem**	**No disturbances or distractions**	**No information available**
Task A	467 (14.92%)	365 (11.67%)	2195 (70.15%)	102 (3.26%)
Task B	504 (16.00%)	309 (9.88%)	2178 (69.61%)	138 (4.41%)
Task C	231 (15.57%)	399 (26.88%)	820 (55.26%)	34 (2.29%)
Task D	231 (15.57%)	269 (18.12%)	946 (63.75%)	38 (2.56%)
Task E	328 (22.10%)	280 (18.87%)	838 (56.47%)	38 (2.56%)

Note. Percentages refer to the samples with informed consent at Wave 1 (N=3129) and at Wave 2 (N=1484), respectively. The category “no information available” refers to videos that could not be coded although no specific details regarding potential disturbances were reported; for these cases, no looking time data is available. The categories “not evaluable” and “multiple/severe disturbances” were collapsed because both ratings resulted in the data not being released. Task A – Task B were administered at Wave 1; Task C – Task E were administered at Wave 2. Task B and Task C featured the same stimulus material.

3.2 Describing the data

For each trial or presented stimulus picture, a number of variables was coded that are available in the public Scientific Use File: Maximum, minimum, mean, total fixation time, and number of fixations on target, as well as off target. This section gives a descriptive overview of total fixation times on target for all habituation-dishabituation tasks, as these have been found to be most stable and reliable (Kavšek, 2004a). Each table reports data for all cases without missing values in the respective task. An explanation of the naming conventions for the reported items in the public Scientific Use File can be found in Figure 3.

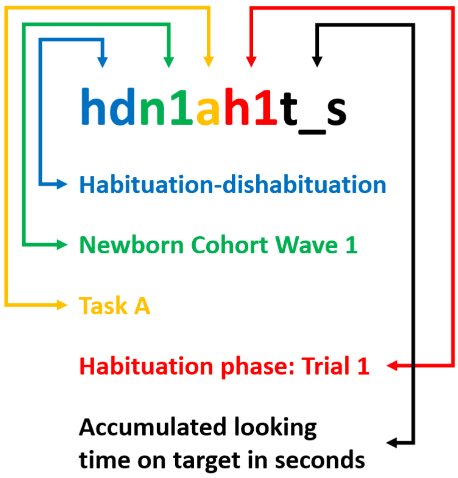

Figure 3. Naming conventions of the reported items on the children's accumulated looking times on target illustrated for the first trial of Task A (Wave 1).

The following descriptive overview features common measures of statistical dispersion to gain insight into the overall distribution of children's total fixation times in all tasks. Skewness indicates whether a distribution is symmetrical and kurtosis is the degree of tail extremity. Values of skewness between 0.5-1 are considered moderately skewed, while values above as substantially skewed (Hair et al., 2014). Values of kurtosis represent either a mesokurtic distribution (=0), a platykurtic distribution (<0) or a leptokurtic distribution (>0). However, as skewness and kurtosis depend heavily on the sample size (Westfall, 2014), these measures are reported as additional information only and not further interpreted.

Table 3 – Table 7 report details on total fixation times, namely the accumulated sum of looking time on target for all trials in each task. Distributions for all trials revealed that longer looking times were more frequent. This is also reflected by the median and the mode. However, comparably many children did not look at the target stimulus at all. The differences in maximum value between 10.03 seconds and 10.07 seconds reflect technical aspects of the coding procedure.

Table 3

Task A: Descriptive Information on Looking Times in all Trials

Variable	M	SD	Median	Mode	Min	Max	Skewness	Kurtosis
hdn1ah1t_s	6.68	2.34	7.00	10.03	0	10.03	-0.65	2.91
hdn1ah2t_s	6.09	2.60	6.41	10.03	0	10.03	-0.45	2.45
hdn1ah3t_s	6.20	2.60	6.60	10.03	0	10.03	-0.53	2.49
hdn1ah4t_s	6.10	2.60	6.44	10.03	0	10.03	-0.46	2.45
hdn1ah5t_s	5.98	2.67	6.30	10.03	0	10.03	-0.40	2.32
hdn1ah6t_s	5.91	2.73	6.23	10.03	0	10.03	-0.39	2.27
hdn1ah7t_s	5.86	2.66	6.07	10.03	0	10.03	-0.34	2.28
hdn1ah8t_s	6.05	2.69	6.40	10.03	0	10.03	-0.45	2.31
hdn1ah9t_s	5.70	2.68	5.97	10.03	0	10.03	-0.32	2.24
hdn1a11t_s	6.18	2.55	6.57	10.03	0	10.03	-0.61	2.74
hdn1a12t_s	5.43	2.57	5.60	0	0	10.03	-0.24	2.30
hdn1a21t_s	5.92	2.54	6.23	0	0	10.03	-0.46	2.48
hdn1a22t_s	5.11	2.56	5.17	0	0	10.03	-0.10	2.27

Note. N=2506; in seconds. Task A refers to the first domain-general habituation-dishabituation task at Wave 1. The variable names correspond to the official data release in the Scientific Use File.

Table 4

Task B: Descriptive Information on Looking Times in all Trials

Variable[5]	M	SD	Median	Mode	Min	Max	Skewness	Kurtosis
hdn1bh1t_s	7.68	2.21	8.23	10.03	0	10.03	-1.07	3.75
hdn1bh2t_s	7.33	2.37	7.83	10.03	0	10.03	-1.04	3.67
hdn1bh3t_s	6.73	2.52	7.10	10.03	0	10.03	-0.66	2.76
hdn1bh4t_s	6.79	2.63	7.27	10.03	0	10.03	-0.76	2.85
hdn1bh5t_s	6.54	2.62	6.90	10.03	0	10.03	-0.59	2.60
hdn1bh6t_s	6.28	2.67	6.53	10.03	0	10.03	-0.51	2.52
hdn1bh7t_s	6.21	2.75	6.53	10.03	0	10.03	-0.49	2.37
hdn1bh8t_s	6.23	2.69	6.60	10.03	0	10.03	-0.51	2.45
hdn1bh9t_s	6.20	2.69	6.50	10.03	0	10.03	-0.51	2.47
hdn1b11t_s	5.79	2.73	6.00	10.03	0	10.03	-0.29	2.19
hdn1b12t_s	5.41	2.69	5.50	10.03	0	10.03	-0.16	2.22
hdn1b21t_s	5.35	2.67	5.53	0	0	10.03	-0.27	2.29
hdn1b22t_s	4.40	2.51	4.30	0	0	10.03	0.16	2.35

Note. N=2478; in seconds. Task B refers to the second domain-general habituation-dishabituation task at Wave 1. The variable names are preliminary.

[5] The current version of the public Scientific Use File (Release 9.1.0) does not include data of Task B, Task D, and Task E. Data of these tasks was processed under a different grant and will be added in future versions of the data set. The variable names reported in Table 4, Table 6, and Table 7 are therefore preliminary.

Table 5

Task C: Descriptive Information on Looking Times in all Trials

Variable	M	SD	Median	Mode	Min	Max	Skewness	Kurtosis
hdn2ch1t_s	8.23	1.85	8.63	10.03	0	10.03	-1.23	4.49
hdn2ch2t_s	8.12	1.86	8.63	10.03	0	10.03	-1.32	4.89
hdn2ch3t_s	7.99	1.99	8.50	10.03	0	10.03	-1.21	4.21
hdn2ch4t_s	8.04	2.02	8.53	10.03	0	10.03	-1.35	4.76
hdn2ch5t_s	7.68	2.15	8.13	10.03	0	10.03	-1.05	3.76
hdn2ch6t_s	7.56	2.23	8.03	10.03	0	10.03	-1.08	4.02
hdn2ch7t_s	7.48	2.27	7.93	10.03	0	10.03	-0.98	3.59
hdn2ch8t_s	7.46	2.30	7.97	10.03	0	10.03	-0.94	3.36
hdn2ch9t_s	7.48	2.32	7.97	10.03	0	10.03	-0.98	3.48
hdn2c11t_s	7.58	2.23	8.03	10.03	0	10.03	-1.02	3.79
hdn2c12t_s	6.87	2.43	7.20	10.07	0	10.07	-0.62	2.65
hdn2c21t_s	7.24	2.26	7.70	10.03	0	10.03	-0.79	3.13
hdn2c22t_s	6.00	2.50	6.13	10.07	0	10.07	-0.18	2.20

Note. N=1131; in seconds. Task D refers to the first domain-general habituation-dishabituation task at Wave 2. The variable names correspond to the official data release in the Scientific Use File.

Table 6

Task D: Descriptive Information on Looking Times in all Trials

Variable[4]	M	SD	Median	Mode	Min	Max	Skewness	Kurtosis
hdn2dh1t_s	8.53	2.14	9.47	10.03	0	10.03	-1.76	5.80
hdn2dh2t_s	7.64	2.35	8.30	10.03	0	10.03	-0.98	3.24
hdn2dh3t_s	7.39	2.46	8.10	10.03	0	10.03	-0.93	3.08
hdn2dh4t_s	6.91	2.61	7.43	10.03	0	10.03	-0.64	2.47
hdn2d11t_s	6.92	2.77	7.60	10.03	0	10.03	-0.65	2.33
hdn2d12t_s	6.29	2.79	6.60	10.03	0	10.03	-0.42	2.21
hdn2d21t_s	7.18	2.40	7.67	10.03	0	10.03	-0.90	3.31
hdn2d22t_s	5.92	2.65	5.93	10.07	0	10.07	-0.19	2.21

Note. N=1167; in seconds. Task D refers to the domain-specific numerical habituation-dishabituation task at Wave 2.The variable names are preliminary.

Table 7

Task E: Descriptive Information on Looking Times in all Trials

Variable[4]	**M**	**SD**	**Median**	**Mode**	**Min**	**Max**	**Skewness**	**Kurtosis**
hdn2eh1t_s	8.67	1.60	9.15	10.07	0	10.07	-1.39	5.25
hdn2eh2t_s	7.99	1.99	8.47	10.03	0	10.03	-1.18	4.26
hdn2eh3t_s	7.80	2.14	8.30	10.03	0	10.03	-1.01	3.39
hdn2eh4t_s	7.23	2.26	7.57	10.03	0	10.03	-0.80	3.13
hdn2eh5t_s	7.25	2.33	7.63	10.03	0	10.03	-0.71	2.87
hdn2eh6t_s	7.36	2.34	7.89	10.03	0	10.03	-0.91	3.28
hdn2eh7t_s	6.92	2.58	7.37	10.03	0	10.03	-0.72	2.73
hdn2eh8t_s	6.56	2.61	6.87	10.03	0	10.03	-0.54	2.44
hdn2eh9t_s	6.46	2.63	6.63	10.03	0	10.03	-0.48	2.36
hdn2e11t_s	6.83	2.60	7.27	10.03	0	10.03	-0.73	2.80
hdn2e12t_s	6.18	2.76	6.37	10.03	0	10.03	-0.37	2.22
hdn2e21t_s	6.99	2.56	7.45	10.07	0	10.07	-0.74	2.87
hdn2e22t_s	6.01	2.67	6.17	10.00	0	10.00	-0.29	2.22

Note. N=1112; in seconds. Task E refers to the domain-specific word-learning habituation-dishabituation task at Wave 2. The variable names are preliminary.

4. Approaches to interpreting the data

In this section, frequently used approaches and measures to interpreting fixation times are discussed and applied to the data from the habituation-dishabituation tasks administered in NEPS SC1. There are two general approaches to interpreting interindividual performance differences in habituation-dishabituation tasks: (I) Calculating index measures of habituation and dishabituation and (II) grouping infants with comparable looking time patterns (data reduction). Most studies use the former approach and there is a number of useful established measures (Colombo et al., 1987; Kavšek, 2004a). The latter approach reduces data by creating groups or profiles based on comparable looking time patterns (McCall, 1979). For the following results, data for all children with no missing values for the respective task was used. The calculations used accumulated looking times, namely the sum of individual fixation times at each trial, with no cut-off criteria applied.

Regarding index measures of habituation and dishabituation, the approaches will be documented in the following way: (I) We provide a general descriptive overview of each measure; (II) we report correlative associations of the measure between all tasks as well as with the children's age; (III) we discuss advantages and disadvantages of the approach in the context of NEPS SC1. Regarding looking time patterns (data reduction), we first discuss cluster analysis and latent profile analysis before illustrating the latter method with NEPS SC1 data, and finally we discuss advantages and disadvantages of the approach.

For testing associations between continuous variables, we chose Pearson correlation. For comparing measures between dichotomous groups, unequal variance t-tests or Welch tests were chosen, as such tests have been shown to be more robust than classic t-tests (Delacre et al., 2017; Ruxton, 2006). Regarding habituation slope, we used growth curve modeling (Duncan & Duncan, 2004). Finally, for findings groups of children with comparable looking time patterns, we used latent profile analysis (Nylund-Gibson & Choi, 2018). Calculations were done in STATA© release 16 (StataCorp, 2019).

4.1 Measures of habituation and dishabituation

Regarding habituation, Kavšek (2004a) provides an overview of commonly used measures for interpreting children's looking times during the habituation phase. Due to the experimental design, stimulus material, and available data, we selected the following measures for the present report: Total fixation time (TFT) and habituation strength (STR) (Colombo et al., 1987). In addition, we selected a dichotomous criterion that indicates whether the child showed a typically expected attention decrement during the habituation phase, namely 50% during the course of habituation trials compared to the initial looking times (HAB) (Fennell, 2012). Finally, habituation slope modeling is introduced as a means to estimate children's attention decrement independent of their overall attention level.

Kavšek (2004a) also provides various measures of dishabituation. However, as NEPS SC1 used a fixed-trial design, only attention recovery (ATR) can be used. The measure indicates the difference in looking times at the transition to the dishabituation phase and uses the last habituation and the first dishabituation trial. Comparable measures sometimes use more than one habituation trial to gain a more robust measure (Oakes, 2010). As we expected relatively high looking times due to the categorical stimulus material and because using only the first dishabituation trial was shown to be the most robust (Kavšek, 2004a), we opted for the present approach.

Habituation: Total fixation time (TFT)

TFT is a measure of accumulated looking time on target during all trials (stimulus pictures) of the habituation phase. Prolonged looking is typically associated with a small attention decrement, which is why higher values are usually interpreted as poor information processing. For the descriptive analysis, we included all cases with no missing values in the respective task. As the total number of habituation trials in Task D was lower than in the other Tasks, TFT is also lower. Table 8 shows that for all tasks, TFT was generally high, as all distributions are left-skewed. Correlations show that TFT of tasks in the same wave tended to have higher coefficients than between the two waves (Table 9). This was expected, as the age range was relatively high at both waves (**3.1 Data base information**).

Although the literature generally focuses on the decrement in looking times during the habituation phase, in the present data, there are many children with long fixation times (see Table 3 – Table 7). Consequently, children with such looking time patterns deviate from typical habituation responses, which also influences other measures such as STR or HAB. In addition, the present sample had the longest looking times for the stimulus material at Wave 2 and TFT only correlated positively with children's age in Task A (Table 9). This was not expected, as older children typically show shorter TFT when compared to younger children (Colombo et al., 2004). However, as laboratory studies usually focus on infants during the first year of life, there are limited findings regarding the development of looking time patterns in the second year of life. Thus, it could be that interindividual age-related differences are substantially smaller in toddlers. It is therefore reasonable to examine children's TFT during the habituation phase in more detail, as it could reflect children's general or sustained attention (Dixon & Smith, 2008).

As an indicator of cognitive functioning, TFT is a convenient measure that can be easily calculated. Previous studies have often used this measure and, compared to other measures, it was found to be robust (Kavšek, 2004a), as it is not as much influenced by local maxima or missing values. In addition, TFT can be interpreted as the amount of overall attention to the stimuli (Ruff, 1986). However, the interpretation of summed up looking times is complex (Oakes et al., 1991). The tasks in NEPS SC1 differed in stimulus material, method, and duration, which is why one cannot expect all tasks to be uniformly related to each other, as well as with later skills or competencies.

Table 8

Descriptive Overview of Total Fixation Time (TFT) in All Tasks.

Variable	N	M	SD	Min	Max	Skewness	Kurtosis
TFT_A	2506	54.59	18.61	1.80	90.27	-0.47	2.65
TFT_B	2474	59.97	16.88	3.40	90.27	-0.63	2.97
TFT_C	1131	70.04	12.66	12.60	90.27	-1.07	4.41
TFT_D	1166	30.46	7.29	1.80	40.16	-1.00	3.59
TFT_E	1112	66.24	13.72	13.03	90.31	-0.65	3.17

Note. Only cases with no missing data in the respective task reported; in seconds. TFT refers to the total fixation time during the habituation phase of the respective tasks at Wave 1 (Task A – Task B) and Wave 2 (Task C – Task E). Task B and Task C featured the same stimulus material.

Table 9

Pearson Correlations of Total Fixation Time (TFT) and Children's Age in All Tasks

	TFT_A	TFT_B	TFT_C	TFT_D	TFT_E
TFT_B	.39**				
TFT_C	.09**	.10**			
TFT_D	.01	.04	.29**		
TFT_E	.03	.05	.32**	.51**	
Children's age	.17**	-.02	-.05	.03	.02

Note. ** $p<.01$. TFT refers to the total fixation time during the habituation phase of the respective tasks at Wave 1 (Task A – Task B) and Wave 2 (Task C – Task E). Task B and Task C featured the same stimulus material.

Habituation: Habituation strength (STR)

STR is a measure of difference between a defined number of trials at the beginning (i.e., fixation baseline) and at the end of the habituation phase (e.g., Domsch et al., 2009; Pahnke, 2007). Positive values indicate that fixation times at the beginning were longer than at the end of the habituation phase, suggesting a typical pattern of looking time decrement. Conversely, negative values indicate that fixation times at the end were longer than at the beginning of the habituation phase, suggesting an atypical looking time pattern. Consequently, positive values should point to efficient stimulus encoding and, thus, good information processing.

Typically, two or three trials are combined to generate robust measures, namely to minimize measurement error (Oakes, 2010). However, there are several reasons why we only used the first and last trial for the present report. For one, the children's looking times at the categorical stimulus material were generally high, which limits variance of STR. In addition, the fixed-trial design resulted in the longest looking times at the first trial of the habituation phase and the shortest looking times at the last trial of the habituation phase. Thus, interindividual differences in looking times should be the most pronounced when considering only these trials. Finally, including more trials would have resulted in limited comparability of Task D with the other tasks, as it featured considerably less trials.

Table 10 shows that for all tasks mean values were sharply peaked. Thus, most values were centered on the empirical mean, which limits variance and, thus, discriminatory ability of the measure between the children. This was probably because many children consistently showed long fixation times during the habituation phase (see Table 3 – Table 7). STR was mostly correlated within each wave, although correlation coefficients were generally small (Table 11). In addition, there were no significant correlations between children's age and STR. Although this was not expected, it can probably be reasoned that the measure does not accompany age differences as well as for example TFT, as it only indicates the relation of fixation times. Thus, any decremental pattern may result in positive values, regardless of the overall visual attention.

Overall, STR is a convenient measure that can be easily calculated and has been used in several previous studies (Attig & Weinert, 2018; Lavoie & Desrochers, 2002; Mayes & Kessen, 1989; Domsch et al., 2009). Still, although there are certain caveats when applying the measure to the data of NEPS SC1. There is no consensus on how many trials to consider when calculating habituation strength. If several trials are considered, variance can decrease and if too few trials are considered, local maxima or minima can bias the results, especially because the tasks in NEPS SC1 used categorical stimuli, which might elicit spontaneous dishabituation. In addition, the present results highlight that intercorrelations were low, which means that task comparability is limited when using STR.

Table 10

Descriptive Overview of Habituation Strength (STR) in All Tasks

Variable	N	M	SD	Min	Max	Skewness	Kurtosis
STR_A	2506	0.11	0.31	-1.00	1.00	0.25	4.99
STR_B	2476	0.14	0.30	-1.00	1.00	0.46	5.60
STR_C	1131	0.06	0.22	-1.00	1.00	0.88	7.46
STR_D	1167	0.12	0.25	-1.00	1.00	0.20	6.57
STR_E	1112	0.18	0.25	-1.00	1.00	0.79	4.91

Note. Only cases with no missing data in the respective task reported. STR refers to the habituation strength during the habituation phase of the respective tasks at Wave 1 (Task A – Task B) and Wave 2 (Task C – Task E). Task B and Task C featured the same stimulus material.

Table 11

Pearson Correlations of Habituation Strength (STR) and Children's Age in All Tasks

	STR_A	STR_B	STR_C	STR_D	STR_E
STR_B	.13**				
STR_C	.09*	.05			
STR_D	.08*	-.03	.09*		
STR_E	.01	.05	.11**	.17**	
Children's age	-.02	.01	-02	-.01	-.05

Note. * p<.05, ** p<.01. STR refers to the habituation strength during the habituation phase of the respective tasks at Wave 1 (Task A – Task B) and Wave 2 (Task C – Task E). Task B and Task C featured the same stimulus material.

Habituation: Habituation criterion (HAB)

For habituation-dishabituation tasks, the decrement during the habituation phase is often measured in a categorical way, namely whether the child reached a pre-defined decrement (e.g., a 50% decrease during the habituation phase, when compared to the initial looking time). Usually, a dichotomous indicator is used for either comparing habituators and non-habituators (e.g., Baillargeon, 1987; McCall, 1979) or the number of trials to reach the criterion (e.g., Dixon & Smith, 2008; Monroy et al., 2019). Conceptually, this measure is used to approximate whether the child habituated during the habituation phase, namely whether the child formed a mental representation of the stimulus material. Consequently, habituators compared to non-habituators are expected to process information faster (particularly in fixed-trial designs), and the measure was shown to predict cognitive skills later in development (Kavšek, 2013). It should be noted that habituation criteria are typically only dichotomous approximations of the looking time decrement during the habituation phase and cognitive theories suggest that the decrement indicates the formation of a mental representation (**Habituation: Habituation slope modelling**).

For the present analysis of NEPS SC1, a cut-off criterion of 50% was used (Cohen, 2004; Fennell, 2012), which means that only children who had a decrement of at least 50% fixation time during the habituation phase in comparison to the initial looking time were seen as successful habituators. Because of the categorical stimulus material, we expected a high amount of non-habituators (Fennell, 2012; Siddle & Glenn, 1974; Slater et al., 1984).

Overall, between 27.59% and 48.29% of all children habituated in the tasks (Table 12). This is at the lower range of typical findings, as usually at least half of the sample habituate in comparable tasks (e.g., McCall, 1979). In addition, it is held that the habituation rate decreases with increasing age of the child, for example, due to maturational changes (Clifton & Nelson, 1976) or increasing experience. Thus, the findings regarding Task B and Task C seem counterintuitive, as both use the same stimulus material. Moreover, HAB was only significantly associated with children's age at Wave 1 (Table 13) – note that the reported results do not control for preterm birth status (**5.3 Child characteristics**). However, HAB is seldom reported in toddlers during the second year of life. It could be that the longer fixation time – and consequently smaller decrements – at Wave 2 were due to qualitative changes in attentional processes. Thus, the comparison between habituators and non-habituators should only be drawn for Wave 1. Still, this does not account for the negative association between children's age and having habituated in Task B. Here, the task could have been too complex for this age group, which is why HAB might primarily indicate effects of fatigue in younger children. Regarding the low number of habituators in Task D, it could be reasoned that the short habituation phase (i.e., four trials) resulted in familiarization (Aslin, 2007), namely only a weak decrease in looking times.

HAB is an often-used measure of decrement in fixation times during the habituation phase (Cohen, 2004; Fennell, 2012; Oakes, 2010). As both the beginning and the end of the habituation phase are included, the measure also indicates interindividual differences in habituation patterns, although fixed-trial designs might underestimate slow habituating children (DeLoache, 1976). Some authors also suggest that only habituators should be considered in further calculations (Cohen, 2004; Oakes, 2010), even though this might exclude a large number of children and probably bias the sample. In addition, while a 50% decrement is generally regarded sufficient, other cut-off values are also used (Fennell, 2012). Thus, it depends on the research question whether to focus on this measure, although it should usually be calculated for means of comparison. In the context of NEPS SC1, subgroups of interest should be checked before formal analyses due to the age range of the children and the categorical stimulus material.

Table 12

Descriptive Overview of Habituated Children in All Tasks

	Total Sample	**Habituators**
Task A	2506	1131 (45.13%)
Task B	2476	1193 (48.18%)
Task C	1131	341 (30.15%)
Task D	1167	322 (27.59%)
Task E	1112	537 (48.29%)

Note. Only cases with no missing data in the respective task reported. Task A – Task B were administered at Wave 1; Task C – Task E were administered at Wave 2. Task B and Task C featured the same stimulus material.

Table 13

Children's Age in the Groups of Habituators and Non-Habituators

	Habituators		**Non-Habituators**				
	M	**SD**	**M**	**SD**	**df**	**t**	**d**
Task A: Children's age	6.89	0.71	7.02	0.71	2422.09	4.45**	0.18
Task B: Children's age	7.00	0.75	6.93	0.66	2393.17	-2.48*	0.10
Task C: Children's age	17.10	0.59	17.02	0.62	663.67	-1.95	0.12
Task D: Children's age	17.03	0.64	17.05	0.59	537.71	0.47	0.03
Task E: Children's age	17.07	0.61	17.04	0.60	1089.87	-0.59	0.04

Note. Children's age reported in months; **p<.01, *p<.05. Task A and Task B were administered at Wave 1; Task C – Task E were administered at Wave 2. Task B and Task C featured the same stimulus material.

Habituation: Habituation slope modeling

Another method to gain insight into children's habituation is to use modeling techniques to estimate a habituation slope. Because cognitive theories hold that the decrement in looking times during the habituation phase indicates the formation of a mental representation of the stimulus material (Colombo & Mitchell, 2009; Kavšek, 2013), habituation slopes should indicate the speed of information processing more directly than other measures. While linear regression models have been used in previous studies (e.g., Ashmead & Davis, 1996), growth curve modeling is a more elaborated way to estimate "interindividual variability in intra-individual patterns of change" (Curran et al., 2010, p. 2). More specifically regarding infant visual habituation-dishabituation tasks, growth curve modeling can be used to estimate differences between the children in intraindividual change across trials. Due to the distinction between fixed (i.e., overall trajectory mean of the sample) and random effects (i.e., individual variance around the overall mean), the intercept and slope can be estimated both for the whole sample, as well as for the individual. Intercept and slope are treated as latent variables that are predicted by the manifest looking times for each trial. For the intercept, fixed factor loadings can be used, while for the slope, the factor loadings can parallel the sequence of stimulus presentation. One example is Monroy and colleagues' (2019) study on visual habituation in deaf children. The authors used growth curve modeling for calculating the growth slope during the first four trials of the habituation phase to examine differences in early language skills between deaf and hearing infants. The slopes were found to be linear for hearing infants, whereas those of deaf infants were fluctuating.

To illustrate this approach with NEPS SC1 data, we calculated unconditional growth models for both tasks at Wave 1 (Table 14). NEPS SC1 has the advantage that due to the fixed-trial design, the children can be compared directly using habituation slope modeling. For Task A and Task B, we included looking times for all nine trials of the habituation phase and calculated models with random intercepts and random slopes (with linear and quadratic growth). In all models, intercept and slope were allowed to correlate with each other as initial looking and looking decrement are typically associated with each other (e.g., Colombo & Mitchell, 2009). Indeed, we found significant correlations between the intercept and slope in most models (Task A Model 1: $r=-.26$, $p<.01$; Task A Model 2: $r=-.17$, $p<.01$; Task B Model 1: $r=-.13$, $p<.01$; Task B Model 2: $r=-.07$, $p=.07$). Estimating a linear and quadratic slope simultaneously resulted in the model not reaching convergence in both tasks. Comparing the models using standard goodness of fit statistics tentatively reveals that for both tasks, a linear growth model fits the data best, although these calculations should not be interpreted as comprehensive because no other variables were controlled for. When applying growth curve modeling to habituation data, individual child characteristics as well as characteristics of the stimulus material should be checked.

One advantage of this approach is that missing data in growth curve modeling can be dealt with by multiple imputation (Duncan et al., 1998) or a Full Information Maximum Likelihood approach (FIML; Acock, 2005; Enders, 2001). In addition to comparing model goodness of fit statistics for linear and polynomial models, factor loadings can be customized to parallel the experimental design. In addition, growth curves can be used to study group differences (e.g., Monroy et al., 2019). Studies on non-linear modeling or polynomial modeling (e.g., Lavoie & Desrochers, 2002) of habituation found that model-based approaches that analyze the intercept and slope of children's looking times separately tend to perform better than the typical habituation criterion. This approach allows for a more fine-grained categorization of whether infants show a systematic decrease during the habituation phase, as well as an increased sensitivity for detecting an increase in the dishabituation phase (Dahlin, 2004; Thomas & Gilmore, 2004). In other words, growth curve modeling allows for estimating the habituation slope, which may be analyzed independent from the overall looking time (i.e., intercept).

However, growth curve modeling is still not frequently used in visual habituation research, probably because it needs a large sample size. Depending on the research design, Curran and colleagues (2010) recommend at least 100 cases (and more for increasingly complex designs). It should be noted, however, that with mixed effects models that effectively also represent estimates of latent growth, sample sizes need not be large (McNeish & Matta, 2018). In addition, estimations are difficult to compare when children's looking time trajectories differ (e.g., linear vs. quadratic) and nearly impossible when the sequence of trials differs, like in many infant-controlled designs. Including many trials in a model also increases complexity, which is why Monroy and colleagues (2019) only used the first four trials because those were the only trials in the infant-controlled design for which all children had valid looking time data.

However, one possible solution is using random-effects pattern-mixture modeling (Hogan & Laird, 1997), which allows for varying lengths in longitudinal data (Young & Hunter, 2015).

Table 14

Exemplary Comparison of Latent Growth Models (Wave 1)

Model	**Change function**	**χ2**	**df**	**CFI**	**SRMR**	**RMSEA**	**AIC / BIC**
Task A Model 1	Linear	418.65**	33	.97	.07	.07	95942.58 / 96065.37
Task A Model 2	Quadratic	537.39**	33	.97	.08	.08	96061.33 / 96184.12
Task B Model 1	Linear	330.54**	33	.97	.06	.06	96543.30 / 96665.47
Task B Model 2	Quadratic	407.87**	33	.96	.08	.07	96620.63 / 96742.80

Note. CFI = comparative fit index; SRMR = standardized root mean square residual; RMSEA = root mean square error of approximation; AIC = Akaike information criterion; BIC = Bayesian information criterion; * $p<0.05$. ** $p<.01$. Task A and Task B refer to the domain-general categorization tasks at Wave 1.

Dishabituation: Attention recovery (ATR)

In NEPS SC1, the stimulus material only featured one picture in the dishabituation phase. Therefore, the orientation response of the children refers to the concept of ATR (Kavšek & Bornstein, 2010). ATR is usually defined as the difference between the fixation times at the first dishabituation and the last habituation trial. Theoretically, the children should show ATR if they perceive the stimulus picture as novel or out of category. Positive values indicate that fixation time at the dishabituation trial was higher than at the last habituation trial, suggesting a typical pattern of renewed attention towards the novel stimulus. Conversely, negative values indicate that fixation times at the last habituation trial were higher than at the dishabituation trial, suggesting that the children perceived the dishabituation trial as familiar. Consequently, positive values should point to good discriminatory abilities and, thus, good attention recovery.

Table 15 shows that for all tasks, mean values of ATR were centered and evenly distributed (overall sample). Still, the high variance suggests that while some children perceived the dishabituation trial as novel and showed positive ATR (novelty effect), others perceived the dishabituation trial as familiar and showed negative ATR (familiarity effect). Thus, for the overall sample, the measure might not be informative, as these two subgroups are collapsed. This is supported by the low intercorrelations of the measure in all tasks (Table 16), although it should be noted that previous studies also found no consistent reliability in dishabituation measures (Colombo et al., 1987; Kavšek, 2004a). In addition, we also tested whether ATR was associated with children’s age. Against our expectations, there were no significant correlations between ATR and children’s age.

Because it is held that habituated children show attention recovery (novelty effect) while non-habituated children show attention decrement (familiarity effect), we used HAB to differentiate between habituators and non-habituators (Table 17). Thus, we used the measure to analyze the looking times for the last habituation trial and the first dishabituation trial between these two groups. T-tests yielded consistent results: In most tasks, habituators showed significantly longer looking times at the novel stimulus (novelty effect), whereas non-habituators had stable or significantly shorter looking times (familiarity effect). These results suggest that habituators and non-habituators show generally typical looking time patterns, which is relevant when working with ATR.

ATR is an informative measure of the children's dishabituation reaction in tasks with a dishabituation phase consisting of individually presented out-of-category exemplars. It allows for assessing the children's behavioral response to a change in stimulus material (Kavšek, 2013; Rose et al., 2004). Even if only one dishabituation trial is considered, as in the case of NEPS SC1, the measure should adequately model interindividual differences in fixation time (Kavšek, 2004a). Still, children's response to the dishabituation phase critically depends on the previous habituation phase as was shown in the present analyses. Still, it should be critically noted that dishabituation measures were generally shown to have no consistent reliability (Colombo et al., 1987; Kavšek, 2004a) and associations between the habituation phase and the dishabituation reaction are probably more complex than often assumed (Jerome et al., 1979). Overall, it depends on the research question and relevant sample (e.g., Kavšek & Bornstein, 2010) whether to focus on ATR when analyzing NEPS SC1 and the measure should always also consider children's habituation.

Table 15

Descriptive Overview of Attention Recovery (ATR) in All Tasks

	N	**M**	**SD**	**Min**	**Max**	**Skewness**	**Kurtosis**
Task A	2506	0.48	2.35	-10.03	10.03	0.03	3.89
Task B	2476	-0.41	2.62	-10.03	10.03	0.07	3.58
Task C	1131	0.10	2.48	-8.57	9.93	0.31	4.37
Task D	1167	0.01	2.93	-9.27	9.63	-0.12	3.16
Task E	1112	0.36	2.57	-9.80	9.10	0.10	3.60

Note. Only cases with no missing data in the respective task reported. ATR refers to the attention recovery during the dishabituation phase of the respective tasks at Wave 1 (Task A – Task B) and Wave 2 (Task C – Task E). Task B and Task C featured the same stimulus material.

Table 16

Pearson Correlations of Attention Recovery (ATR) in All Tasks

	ATR_A	ATR_B	ATR_C	ATR_D	ATR_E
ATR_B	-0.04				
ATR_C	-0.04	.00			
ATR_D	0.01	-0.01	0.00		
ATR_E	-0.01	0.08*	0.08*	0.02	
Children's age	.03	-.01	.01	.01	-.02

Note. * p<.05. ATR refers to the attention recovery during the dishabituation phase of the respective tasks at Wave 1 (Task A – Task B) and Wave 2 (Task C – Task E). Task B and Task C featured the same stimulus material.

Table 17

Looking Times in Habituators and Non-habituators

		Trial 9		Trial 10				
		M	SD	M	SD	df	t	d
Task A	Habituators	4.10	2.57	5.13	2.70	1391	-13.49**	0.39
	Non-habituators	6.98	2.00	7.01	2.08	1163	-0.60	0.02
Task B	Habituators	4.85	2.75	4.73	2.68	1193	1.46	0.04
	Non-habituators	7.45	1.9	6.77	2.39	1288	10.60**	0.31
Task C	Habituators	5.87	2.81	6.45	2.68	380	-3.51**	0.21
	Non-habituators	8.07	1.76	7.89	2.00	837	2.42*	0.09
Task D	Habituators	4.46	2.57	5.48	2.95	339	-5.51**	0.37
	Non-habituators	7.81	1.94	7.40	2.54	875	4.65**	0.18
Task E	Habituators	5.09	2.70	5.79	2.73	539	-5.57**	0.25
	Non-habituators	7.73	1.81	7.80	2.03	574	-0.71	0.03

Note. Children's looking times reported in seconds; ** p<.01, * p<.05. Task A and Task B were administered at Wave 1; Task C – Task E were administered at Wave 2. Task B and Task C featured the same stimulus material. Trial 9 was the last trial of the habituation phase, whereas Trial 10 was the first dishabituation trial.

4.2 Data reduction methods

Apart from using index measures that are calculated by using the looking times of each respective trial to interpret individual task performance, there are several studies that use data reduction methods to create groups that can be compared regarding differential developmental patterns (Bronson, 1991; Richards & Cameron, 1989). In previous research, McCall (1979) found age-related differences in the habituation phase when using cluster analysis as a data reduction method. Infants at 5 months were clustered into three groups (i.e., monotonically decrease; decrease-increase; increase) and infants at 10 months were clustered into five groups, that were generally flatter and more mixed. Another use of cluster analysis can be found in Baillargeon (1987), who found three groups in a sample of 3-4 month-old-infants (i.e., fast habituators; slow habituators; mixed group).

Cluster analysis as a data-led method might reveal coherent interindividual looking time patterns, which can be compared to theoretically expected ones. The groups are usually interpreted in a straightforward manner, as the individual looking time at the stimulus material does not have to be analyzed in detail. However, cluster analysis based on observable visual behavior also has drawbacks. It could be shown that the clusters might represent statistical artifacts when the underlying habituation function includes an additive random error. This has a detrimental effect on the estimated expected number of clusters when the patterns between the groups are similar (Gilmore & Thomas, 2002). Additionally, cluster analyses cannot statistically verify the number of groups and therefore assign group number only categorically (Dolnicar, 2002). Some studies, for example, create a group of children with a mixed profile, without explaining what the benefit of such a heterogeneous group is (e.g., Baillargeon, 1987; McCall, 1979). Longitudinally, it is also difficult to find stability, as children's looking time patterns often change – something, that cluster analyses do not automatically reflect (Kavšek, 2004a; McCall, 1979). In addition, for large sample sizes the patterns are much more difficult to interpret because cluster assignment is influenced by group size (Siddiqui, 2013). Finally, although clusters can empirically be found, they may represent statistical artifacts because they underlie the same basic habituation function (Gilmore & Thomas, 2002).

As a possibility to deal with two main statistical issues of cluster analysis, namely that the number of groups cannot be statistically determined and the impact of statistical artifacts on how group membership is assigned, latent profile analysis can be used. Although to the knowledge of the authors, there have been no studies so far that implemented latent profiles in infant habituation research, it should allow for a probabilistic way to assign children to specific groups of looking time patterns and even statistically compare models with different group sizes.

Probabilistic clustering methods are useful for classifying individuals into groups of profiles based on conditional probabilities. With continuous variables (i.e., fixation times) and categorical outcomes (i.e., group membership), probabilistic clustering is often referred to as latent class analysis (Fairley et al., 2014) or latent profile analysis (Dean & Raftery, 2010; Vermunt & Magidson, 2002). Latent profile analysis assumes a statistical model for the population of the current sample and estimates the similarity of the individuals from their observed scores on a set of indicators that share the same probabilistic distributions. Group membership is therefore estimated by the probability of being a member of a latent class and the class-specific normal density (Tein et al., 2013; Vermunt & Magidson, 2002). The posterior group membership assigns the classes to those with the highest similarity of the observed scores and the class-specific normal density (Vermunt & Magidson, 2002). In addition, latent profile analysis allows for incorporating missing data by applying multiple imputation (Duncan et al., 1998) or Full Information Maximum Likelihood (FIML; Acock, 2005; Enders, 2001) (see Fairley et al., 2014). Finally, group sizes can be compared via standard goodness of fit measures (Vermunt & Magidson, 2002), such as AIC, CAIC, BIC/SIC, and sample size adjusted BIC (Nylund et al., 2007). In short, the sequence of habituation or dishabituation trials can be used as manifest variables to estimate latent looking time profiles, based on the looking times of all children in the sample.

To illustrate this approach with NEPS SC1 data, we calculated latent profile analysis for all trials in the habituation phase of Task A. To avoid solutions based on local maxima and to increase robustness of the findings, 100 random sets of starting values were defined. Typically, AIC, BIC, and entropy are used to assess the quality of the respective profile solutions (Celeux & Soromenho, 1996). When comparing the present profile solutions (Table 18), entropy started to fall with the 4-profile solution and with a growing number of classes, profile size also decreases, limiting the interpretation of the results (Tein et al., 2013), so we chose the 3-profile solution, which also matches the number of clusters McCall (1979) found.

Table 18

Selected Solutions of Latent Profile Analysis (Task A)

	AIC	**BIC**	**Entropy**
2 Profiles	98120.09	98283.23	.97
3 Profiles	95356.42	95577.82	.97
4 Profiles	94474.98	94754.65	.96

Note. AIC = Akaike information criterion; BIC = Bayesian information criterion. Task A refers to the first domain-general categorization task at Wave 1.

Table 19 reports descriptive data on children's mean looking times in Task A. For all profiles, fixation times tended to decrease during the habituation phase, although the decrement was smaller than what is typically expected (e.g., Colombo et al., 2004). However, the profiles were markedly different in the initial looking times (i.e., the first trial) as well as in the overall level of looking times (Figure 4). Thus, the profiles do not differ with regard to the decrement in looking times but rather with regard to the overall looking time at the target.

Table 19

Descriptive Overview of Mean Fixation Times in Latent Profiles (Task A)

	Profile 1: M (SD)	**Profile 2: M (SD)**	**Profile 3: M (SD)**
hdn1ah1t_s	3.83 (2.08)	6.30 (1.91)	8.02 (1.71)
hdn1ah2t_s	2.56 (1.87)	5.54 (1.95)	7.82 (1.74)
hdn1ah3t_s	2.53 (1.87)	5.57 (1.91)	8.04 (1.56)
hdn1ah4t_s	2.39 (1.72)	5.43 (1.88)	8.00 (1.53)
hdn1ah5t_s	2.37 (1.81)	5.09 (1.90)	8.05 (1.51)
hdn1ah6t_s	2.23 (1.80)	5.03 (1.96)	8.01 (1.58)
hdn1ah7t_s	2.30 (1.82)	5.03 (1.91)	7.86 (1.60)
hdn1ah8t_s	2.51 (2.03)	5.30 (2.07)	7.97 (1.59)
hdn1ah9t_s	2.28 (2.00)	4.98 (2.04)	7.56 (1.78)

Note. Profile 1 (N=378); Profile 2 (N=1027); Profile 3 (N=1101); fixation times in seconds. Task A refers to the first domain-general categorization task at Wave 1.

Next, we examined differences in children's age between the three profiles. Descriptively, children in Profile 1 were youngest ($M=6.75$, $SD=0.65$), while children in Profile 3 were oldest ($M=7.08$, $SD=0.73$), and Profile 2 was in-between ($M=6.91$, $SD=0.69$). Regression analysis and post-hoc tests showed that the level differences between all three classes were significant; Profile 1 and Profile 2: $F(1, 2499)=15.12$, $p<.01$; Profile 1 and Profile 3: $F(1, 2499)=61.10$, $p<.01$; Profile 2 and Profile 3: $F(1, 2499)=28.65$, $p<.01$. The results suggest that younger children spent less time looking at the stimulus material, while older children show prolonged looking times, which is counterintuitive given the typically decreasing looking times in habituation-dishabituation tasks with increasing age (e.g., Colombo et al., 2004). As the overall slope of looking times during the habituation phase was comparable between the profiles, we reason that the youngest children (Profile 1) were maybe more uncomfortable with the observational setting and, therefore, focused less on the stimulus material.

Thus, using data reduction methods, the pattern of results for Task A is not similar to findings from the literature. In 5-month-old infants, McCall (1979) reported two clusters with fluctuating patterns, while a third cluster showed a typical decrement during the habituation phase. As the present findings suggest rather stable interindividual looking times across trials, this can probably be attributed to the categorical stimulus material, which was shown to result in prolonged looking behavior and greater engagement in the task, especially in older children (Courage et al., 2006; Fennell, 2012). In addition, prolonged looking behavior might be a result of the familiar setting in the children's home compared to standard laboratories, which activated the children more during task administration (Wass & Leong, 2016). As the three profiles mainly reflect level differences, this might indicate that the task discriminated between overall visual attention instead of information processing. Thus, when applying data reduction methods, the patterns need to be contrasted to theoretical assumptions about looking time patterns in general (Colombo & Mitchell, 2009) as well as specific empirical findings reported in the relevant age range (Colombo et al., 2004).

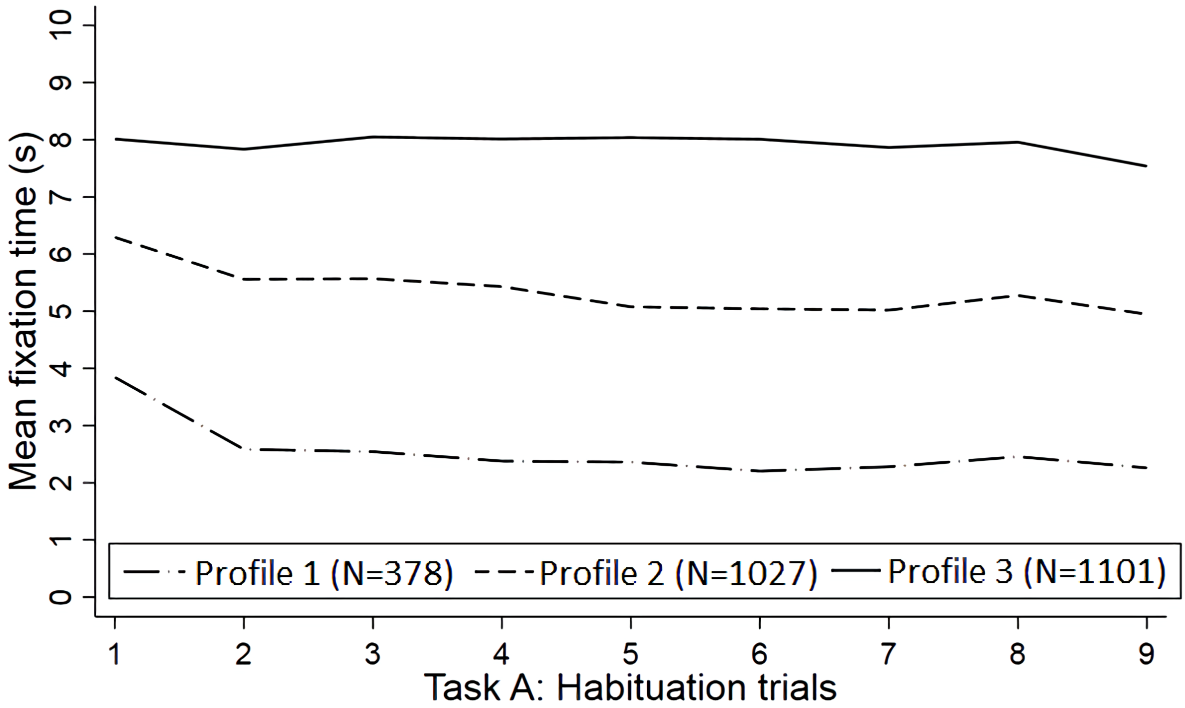

Figure 4. Fixation time patterns during the habituation phase of Task A for all three profiles. Task A refers to the first domain-general categorization habituation-dishabituation task at Wave 1.

5. Data selection

As data selection criteria have a great influence on calculating and interpreting fixation times (Fennell, 2012; Kavšek, 2004a; Oakes, 2010), this chapter presents further information on how the children's looking times can be approached from a methodological standpoint. Specifically, short looking times, relevant child characteristics, and disturbances during the observation are discussed. Finally, we provide information on possible forms of data transformation.

5.1 Handling short looking times

To make sure that the children's looking times can be interpreted as a valid indicator for having processed the presented stimuli adequately, cut-off criteria for short fixation times (i.e., short episodes of looking at the target) are often used (Oakes, 2010). However, as Colombo and Mitchell (2009) note, there is no consensus in the literature on what cut-off criterion to use. Some authors suggest that within a range of 0.5-1 seconds, cutting off values does not result in systematically different results (Colombo & Mitchell, 1990), while others argue that single looking time events should not be smaller than 400 milliseconds (Kavšek, 2013). In experiments on sustained attention in infants, it could be shown, that through a change in heart rate, a minimum of about 1 second is required, following stimulus onset. This has been interpreted as a stimulus orienting response of the infants, which likely reflects attentional processing (Richards & Casey, 1992). In studies on sustained deceleration (Colombo et al., 2004) and in studies with more complicated stimulus material (Cohen et al., 1975), even higher cut-off values have been discussed. Thus, many authors argue that cut-off criteria can reduce local maxima, which influences measures of habituation and dishabituation.

However, cut-off values are often arbitrary and differ vastly among studies (Colombo & Mitchell, 2009). A certain amount of data will be defined as invalid, when in reality the looking time event might have contributed to how the infant processed the stimulus. For reaction time tasks, it was shown that truncated looking times can bias results and distort linear relationships because valid events of stimulus processing are excluded (Ulrich & Miller, 1994). Moreover, cut-off criteria usually lead to an increase in missing values and dropout of cases. Finally, most studies with cut-off criteria have infant-controlled designs. In such studies, the elimination of small looking times events is directly related to reaching the habituation criterion and, thus, how long the stimulus material is presented (e.g., Bornstein & Suess, 2000; Brooks & Meltzoff, 2008; Colombo et al., 2004; Mayes & Kessen, 1989). To the knowledge of the authors, there have been no methodological studies on whether short looking time events have a comparable impact in fixed-trial designs.

In the context of NEPS SC1, an extreme example of short looking times are cases with zero looking times (i.e., the child did not look at the target during the 10 second interval). Handling such cases becomes relevant when one decides against using cut-off criteria. These cases do not represent missing values in a traditional sense (e.g., Graham, 2009). Rather, such zero looking times indicate that external or internal factors resulted in the child having looked away from the target in the respective interval. Overall, children showed no looking time on target for a number of trials (Wave 1: Table 20; Wave 2: Table 21). In Wave 1 (Task A: N=414; Task B: N=517), the number of cases with zero looking times was generally higher than in Wave 2 (Task C: N=61; Task D: N=85; Task E: N=117).

Table 20

Number of Trials with Zero Looking Time on Target (Wave 1)

	Task A	**Task B**
No zero looking times	2092 (83.48%)	1959 (79.12%)
1	224 (8.94%)	281 (11.35%)
2	90 (3.59%)	106 (4.28%)
3	36 (1.44%)	57 (2.30%)
4	22 (0.88%)	36 (1.45%)
5	7 (0.28%)	20 (0.81%)
6	11 (0.44%)	8 (0.32%)
7	12 (0.48%)	6 (0.24%)
8	4 (0.16%)	2 (0.08%)
9	1 (0.04%)	0
10	5 (0.20%)	1 (0.04%)
11	2 (0.08%)	0
12	0	0
13	0	0

Note. All cases considered with video recordings and available looking time data (without missing values); all respective trials considered. Task A – Task B refer to the domain-general categorization habituation-dishabituation tasks at Wave 1.

Thus, although most of the children do not show zero looking times, the issue should be addressed when working with the data of NEPS SC1. The descriptive overviews also suggest that the number of cases with no looking time towards the target tends to increase during the sequence of tasks at each wave (Table 20; Table 21). As fixed-trial designs are used to study interindividual differences, trials with zero looking time on target should not be critical when they are randomly distributed, for example, due to unsystematic internal or external factors. However, they are potentially problematic when there is a systematic influence. When zero looking times indicate task systematic interruptions or distractions such as external (e.g., distractions of other people or loud noises) or internal events (e.g., sleepiness/fussiness of the child), such cases should be excluded (Jones, 2019).

Table 21

Number of Trials with Zero Looking Time on Target (Wave 2)

	Task C	**Task D**	**Task E**
No zero looking times	1070 (94.61%)	1082 (92.72%)	995 (89.48%)
1	40 (3.54%)	66 (5.66%)	78 (7.01%)
2	14 (1.24%)	13 (1.11%)	27 (2.43%)
3	3 (0.27%)	5 (0.43%)	6 (0.54%)
4	1 (0.09%)	1 (0.09%)	3 (0.27%)
5	1 (0.09%)	0	2 (0.18%)
6	1 (0.09%)	0	1 (0.09%)
7	0	0	0
8	1 (0.09%)	0	0
9	0	-	0
10	0	-	0
11	0	-	0
12	0	-	0
13	0	-	0

Note. All cases considered with video recordings and available looking time data (without missing values); all respective trials considered in each task. Task C – E refer to the habituation-dishabituation tasks at Wave 2.

Overall, handling short looking times depends on the research question. When using the habituation-dishabituation tasks in NEPS SC1 to investigate early predictors of later cognitive abilities, most cut-off criteria are not likely to influence the overall pattern of results and may be regarded as measurement error – even though the error should not be completely at random (Gilmore & Thomas, 2002). When investigating the available looking time data from a methodological standpoint, however, short looking time events should be analyzed more thoroughly and different cut-off criteria should be considered and possibly compared. Still, it should be noted that looking time data in current data releases of NEPS SC1 does not allow for investigating different underlying processes of visual attention in detail (i.e., orienting attention and selective engagement; Reynolds, 2015) because only accumulated looking times are available. When cut-off criteria are not considered, zero looking times need to be addressed. Although cases with a substantial amount of zero looking times were rare, they should be excluded from the analysis, as it can be reasoned that the stimulus material was not sufficiently processed. Still, some authors argue that including zero looking times does not generally bias results and leads to an increased sample size (Colombo & Mitchell, 1990), which is why robustness checks should be done after applying a cut-off criterion. At least when examining specific trials (e.g., for calculating certain measures or when focusing on the dishabituation phase), cases with zero looking times should not be included without robustness checks.

5.2 Disturbances

In infant studies, child-related disturbances are frequently reported such as fussiness (see Slaughter & Suddendorf, 2007), drowsiness, crying, excessive movements, irritability, and restlessness or falling asleep. These cases are usually excluded because such disturbances influence if and how the child participates during the task and how the stimulus material is processed. At the first two waves, the coders of the video recordings protocolled child-related disturbances for each task. Table 22 shows that reported child-related disturbances were marginal in the overall sample with informed consent, especially when compared to studies conducted in a laboratory setting (Slaughter & Suddendorf, 2007). It should be noted, however, that cases in which video recordings could not be started or finished due to child-related disturbances, could not be covered this way.

Table 22

Descriptive Overview of Child-Related Disturbances in the Habituation-Dishabituation Tasks

	No child-related disturbance	**Child-related disturbances**	**No information available**
Task A	2985 (95.40%)	24 (0.77%)	120 (3.83%)
Task B	2915 (93.16%)	68 (2.17%)	146 (4.67%)
Task C	1366 (92.05%)	25 (1.68%)	93 (6.27%)
Task D	1228 (82.75%)	35 (2.36%)	221 (1.89%)
Task E	1215 (81.87%)	69 (4.65%)	200 (13.48%)

Note. All cases considered with informed consent at Wave 1 (N=3129) and at Wave 2 (N=1484), respectively. Task A – Task B refer to the habituation-dishabituation tasks at Wave 1; Task C – Task E refer to the habituation-dishabituation tasks at Wave 2.

Such extremely low numbers of child-related disturbances were unexpected but probably a result of the familiar environment. Thus, most children can be regarded cooperative during the habituation-dishabituation tasks in both waves. The household setting could have been responsible for the children's level of participation and sustained attention. However, NEPS SC1 has limited information on the immediate environment of the children, namely qualities of the household. Examples are stressful and chaotic features of the immediate environment. Household chaos refers to aspects that may confuse young children, such as disorganized structures and hurriedness in the home, especially if these disturbances happen severely and chronically (for an overview, see Emond, 2020). Such stressful contexts were already shown to be associated with reduced information processing in 5-month-old infants (Tomalski et al., 2017) and may result in the detrimental development of school-related skills and competencies (Martin et al., 2012). This might also increase measurement error during habituation-dishabituation tasks, as well as influencing children's attention selectively, although given the present number of disturbances such cases in the data of NEPS SC1 should generally be rare.

5.3 Child characteristics

Child characteristics relevant for interpreting habituation and dishabituation include preterm birth (i.e., <37 weeks of gestation; Kavšek & Bornstein, 2010), low birthweight (i.e., <2000g; Hack et al., 1995), post-term birth (i.e., >42 weeks of gestation; Bornstein et al., 2013), visual/hearing impairment (Kavšek & Bornstein, 2010) depending on the stimulus presentation, and later reported developmental disability (Brian et al., 2003). Usually, these cases should be controlled for or excluded because they often indicate prematurity, which is problematic when examining interindividual differences (Kavšek & Bornstein, 2010; Ohgi et al., 2003; Ortiz-Mantilla et al., 2008). In addition, preterm low birthweight infants were found to have a higher variance in their looking time patterns than full-term infants (Thomas et al., 1998), which could result in statistical artifacts. Children born preterm are often excluded, especially if habituation and dishabituation are used for predicting later abilities and competencies. In NEPS SC1, there was only a small subsample of children born preterm and children born post-term were the exception (Table 23).

Table 23

Birth Status of NEPS SC1 Children

	Full-term	Preterm	Post-term
Task A	2349 (93.74%)	143 (5.71%)	14 (0.55%)
Task B	2317 (93.58%)	146 (5.90%)	13 (0.52%)
Task C	1062 (93.90%)	62 (5.48%)	7 (0.62%)
Task D	1094 (93.74%)	66 (5.67%)	7 (0.59%)
Task E	1048 (94.24%)	57 (5.13%)	7 (0.63%)

Note. All cases considered with available looking time data (without missing values). Task A – Task B refer to the habituation-dishabituation tasks at Wave 1; Task C – Task E refer to the habituation-dishabituation tasks at Wave 2.

Regarding children's health, it should be noted that there is no exact information on nutritional status at both waves, although information of the routine medical examinations is included (i.e., information from the child health record books). At least for malnourished 12-month-old infants, it was shown that habituation to auditory signals was substantially associated with belated or absent orientation response and a lack of dishabituation (Lester, 1975) – although differences only showed in severely malnourished infants (Lester et al., 1975). Using a visual preference study, Lasky and Klein (1980) also supported the notion that malnourished children compared to well-nourished children respond to a lesser extent to novel stimuli. However, for the German population, such cases should be extremely rare (McCarthy et al., 2019). Regarding more unstable child characteristics such as mild illness, research is scarce. However, one previous study found no systematic effect on habituation patterns, except for a higher rate of fatigue (Haskins et al., 1978).

Finally, child temperament (e.g., effortful control and surgency) has been suggested to be associated with children's visual attention (Papageorgiou et al., 2015) and, thus, with their performance in habituation-dishabituation tasks. It was found, for example, that infants with an agitated temperament were less likely to complete a habituation task at 4 months (Bell et al., 1998; Bell et al., 2002; similarly Treiber, 1982) – see Mink and colleagues (2013) for contrasting findings regarding dropout rates. This effect could be associated with the child's gender (Wachs & Smitherman, 1985). In previous analyses of NEPS SC1, child temperament (i.e., negative affectivity) was positively associated with total fixation time during the habituation phase in Task A (Weinert et al., 2017) but not in Task C (Attig & Weinert, 2018). Similarly, in categorical habituation tasks, fearful (Rieser-Danner, 2003) and distressed children (Vonderlin et al., 2008) were less likely to show a typical looking time pattern (i.e., familiarity with the test administrator and testing environment).

5.4 Multiple family languages

In cognitive research, it has been suggested that children growing up with multiple languages at home, namely crib bilinguals (e.g., Kovács, 2016), may have several advantages. Typically, researchers point out specific developmental differences between monolinguals and bilinguals regarding gray matter density in the left parietal cortex (García-Pentón et al., 2014) and higher executive functions, covering inhibitory control, monitoring, and attention switching (Diamond, 2013). Overall, results are still inconsistent regarding the domain-specificity of such a bilingual advantage (Bialystok, 1999; Kovács & Mehler, 2009; but see Paap & Greenberg, 2013; Samuel et al., 2018). Theoretically, it is reasonable that domain-general cognitive processes are impacted by the exposure to more than one language during infancy. Indeed, Singh and colleagues (2015) found that 6-month-old bilingual infants showed faster information processing and better recognition memory than monolinguals. They used an infant-controlled habituation-dishabituation task with identical stimulus material and found significant advantages in bilinguals for several measures (i.e., attention decrement, habituation slope, and novelty preference). The authors, thus, argue for a domain-general advantage of bilinguals over monolinguals that comprises basic visual information processing and emerges in the first months of life.

Still, it should be noted that regarding bilingual language exposure, data in NEPS SC1 is limited and often confounded with other variables of interest. Thus, not all challenges of bilingualism research can be met with the dataset (e.g., context of exposure or language dominance; Werker & Byers-Heinlein, 2008).It should be carefully considered if and how family language can be controlled for, when using habituation-dishabituation tasks for indicating early cognitive abilities. Although previous studies found a domain-general effect in a sample of 6-month-old infants (Singh et al., 2015) and possibly differences in the novelty effect of bilingual and monolingual infants (Singh, 2021), there have been very few comparable studies.

5.5 Data transformation

As other reaction time based experimental designs, looking time data in habituation-dishabituation tasks are usually left-skewed (e.g., Farroni et al., 2005; Leslie & Chen, 2007). If the data is heavily skewed (i.e., not normally distributed and/or without homogeneous standard deviations), traditional parametric statistical approaches (e.g., t-test or regression analysis), will not produce reliable results (Chin & Lee, 2008), resulting in biased estimators and confidence intervals that cannot be adequately interpreted (Ernst & Albers, 2017; Williams et al., 2013). To generate normally distributed data, there are several approaches. One approach is to identify and eliminate outliers (e.g., Beier & Spelke, 2012; Jones, 2019;

Wagner & Carey, 2005). However, excluding certain values is often arbitrary in disregarding data and inefficient when the data structure is complex. Another approach is to use non-parametric tests (Havron et al., 2020) that make fewer assumptions about the data distribution (i.e., normally distributed residuals; Rasmussen & Dunlap, 1991) but are also generally less powerful than parametric tests (Chin & Lee, 2008). Lastly, in infant habituation research, logarithmic data transformation has sometimes been used to produce log-normal distributions (e.g., Bornstein et al., 2013; Dunn & Bremner, 2016; Mayes & Kessen, 1989; Woodward, 1998). However, other types of transformations have also been used, for example arcsine/angular (Barten & Ronch, 1971; Imafuku et al., 2019) or square-root transformation (Colombo et al., 1987; Millar & Weir, 1995). In comparing looking time data to general reaction time data (see Whelan, 2008), Csibra and colleagues (2016) noted that due to the non-arbitrary zero point, the continuously positive types of measurement, and the possibility to interpret accumulated fixation times proportionally to each other, looking time data might follow a log-normal distribution. At least when using proportions of looking times for sequential stimuli, the authors recommend transforming the data logarithmically. Regarding NEPS SC1, most previous analyses transformed the data logarithmically due to the characteristics of the distribution (Attig & Weinert, 2018; Hondralis & Kleinert, 2021).

6. Summary and Conclusion

In NEPS SC1, visual habituation-dishabituation tasks were administered in the first two waves, namely when the children were on average 7 and 17 months. Domain-general categorization and domain-specific tasks tapping early quantitative abilities and word learning were administered in the children’s home by trained interviewers. Compared to typical infant studies, NEPS SC1 provides rich data on the children’s socioeconomic background and the sample is relatively heterogeneous, which is especially important for analyzing structural and environmental factors. For the habituation-dishabituation tasks, the Scientific Use File provides a range of information on children’s looking times on and off target. This technical report presented selected insights into how the data may be approached, although not all aspects could be elaborated in detail. As examples of often-used measures, we included total fixation time (TFT), habituation strength (STR), habituation criterion (HAB), habituation slope, and attention recovery (ATR) (Colombo et al. , 1987; Kavšek, 2004a). In addition, the possibility of analyzing children’s looking time patterns with data reduction methods was discussed. Overall, it depends on the research question what approach to use.

The familiar setting in the children’s home probably resulted in atypical looking time patterns in the habituation and dishabituation phases of most tasks. Although one previous study found no systematic difference in looking times between household and laboratory setting (Bornstein & Ludeman, 1989), we suspect that the familiar environment facilitated children’s attention. In other words, the habituation-dishabituation tasks in NEPS SC1 could have higher ecological validity when compared to standardized laboratory environment. We found that looking times at the target were generally high and only subgroups of children showed a decrease in fixation times in the habituation phase. Still, NEPS SC1 only provides a limited amount of information regarding potential effects of the children’s immediate environment (e.g., interruptions by parents or siblings, lighting, traffic noise). However, while there could be numerous reasons why a household setting might influence the children’s attention negatively, overall the opposite seems to be the case as a large amount of children participated in the tasks without any interruptions or disturbances, which is a central strength of the data.

Regarding interindividual differences in habituation and dishabituation, we found only few significant correlations between children's age and fixation time on target. Previous studies suggest that, because fixation times indicate processing speed, they should decline with age (Ropeter & Pauen, 2013). Because older children process visual information more quickly, they should also habituate more efficiently (Colombo et al., 1988; Kavšek, 2004a). However, as other authors have already suggested, the relationship between looking times as a quantitative measure and the quality of information processing is not fully understood because looking times may indicate processing of local and/or global features (Freeseman et al., 1993). In addition, typically only the first year of life is investigated in the literature; thus, interindividual differences regarding the children's age could be substantially smaller in the second year of life, due to maturational changes.

Overall, our findings suggest that total fixation time in NEPS SC1 indicates a form of sustained attention (Ruff, 1986), while in laboratory studies children with consistently high looking times would be categorized as non-habituators or slow habituators (e.g., McCall, 1979). It is generally held that children with long fixation times have poorer processing speed than children with a typical decrement in the habituation phase (e.g., Ropeter & Pauen, 2013; Sigman et al., 1997). Thus, showing prolonged looking time during the habituation phase or not reaching the habituation criterion was frequently shown to be associated with poorer cognitive outcomes (e.g., McCall & Carriger, 1993; Teubert et al., 2011). However, there is also evidence suggesting that the effect of attention decrement during the habituation phase on language skills might be moderated by attentional focus (Dixon & Smith, 2008). Here, the authors found that for children with high attention focus, processing speed was positively related to productive vocabulary at 20 months – so, children with longer fixation times and consequently a weaker habituation decrement had higher language skills if they also had high attentional focus. The authors conclude that volitional attention is probably an underlying mechanism, which is why slow habituation should not generally be regarded as poor performance. The present data also indicates that long looking times, and consequently slower habituation, should be examined more carefully (see Colombo et al., 2004).

One limitation of the experimental design of the habituation-dishabituation tasks in NEPS SC1 was the lack of a randomized task order. At both waves, the sequence of the tasks was fixed, which makes it impossible to disentangle effects of categorization, attentional processes, and task sequence, which is why direct comparisons between the tasks is not possible, even if Task B and Task C effectively used the same stimulus material. However, the fixed sequence also makes large-scale group comparisons easier, which was the focus of NEPS SC1. Additionally, only tasks with a fixed-trial design were administered which are often criticized as outdated because many children might not habituate properly (Bornstein & Sigman, 1986; but see Haaf et al., 1983). As a result, some children might not identify the dishabituation stimulus as novel, while others might have already habituated early on. This is why some authors prefer the term familiarization for such designs instead of habituation (Aslin, 2007; Oakes, 2010). Still, in the large-scale context of NEPS SC1, the fixed-trial design was deemed useful, as it allowed for a high degree of standardization and certain elements of infant-controlled tasks were seen as problematic (i.e., interviewer experience and online coding). In addition, analyzing the looking time behavior in habituators and non-habituators revealed consistent patterns that matched our previous expectations. Thus, NEPS SC1 is useful for identifying interindividual differences in early cognitive functioning on a group level (Colombo & Mitchell, 2009).

One important benefit of NEPS SC1 is that habituation-dishabituation tasks were administered to a large and heterogeneous sample in a household setting. Thus, there is rich data on the children's socioeconomic background, family, home learning environment, social capital or other cultural resources, regional information (Weinert et al., 2016), as well as longitudinal competence data (Artelt et al., 2013; Weinert et al., 2019). As habituation-dishabituation tasks may be used to examine early cognitive abilities as well as the effects of such precursors on later skills and competencies, the data offers numerous possibilities for extending, replicating, and verifying existing results as well as gaining knowledge about how children's immediate environment influences their cognitive development (e.g., Bronfenbrenner & Morris, 2006).

7. References

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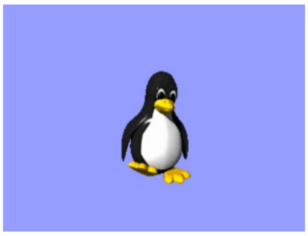
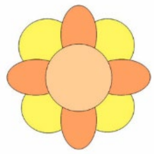
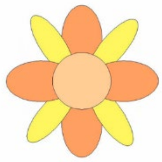
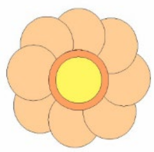
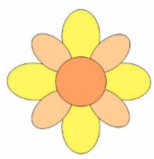
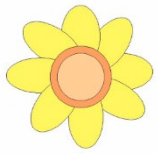
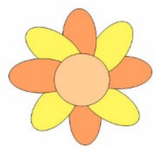
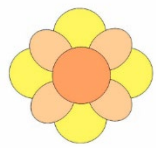
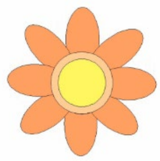
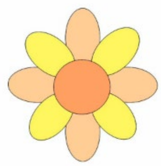
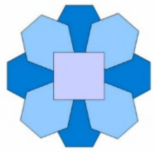
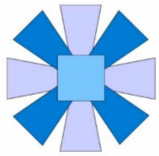
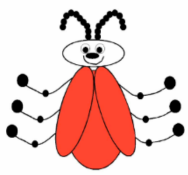
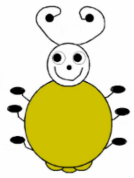
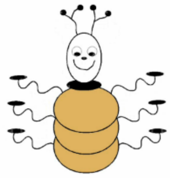
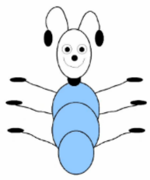
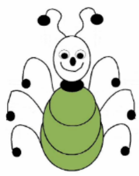
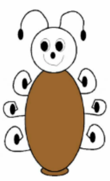
8. Appendix: Stimulus material

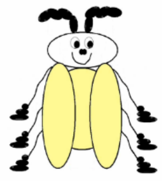
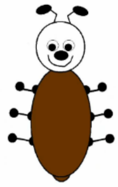
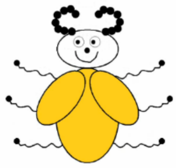
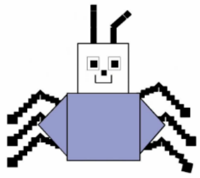
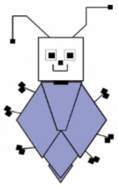
Wave 1: Presentation sequence of the stimulus material

Trial	Task	Presentation time *(seconds)*	Stimulus
--	Attention getter	3	
1	Task A Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
2	Task A Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
3	Task A Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
4	Task A Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*

Trial	Task	Presentation time *(seconds)*	Stimulus
5	Task A Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
6	Task A Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
7	Task A Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
8	Task A Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
9	Task A Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*

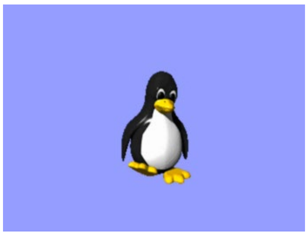
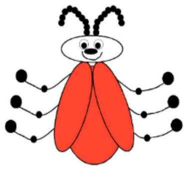
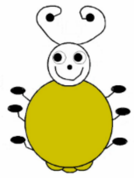
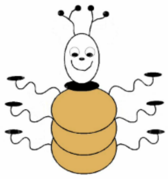
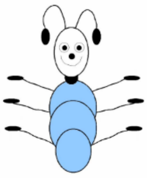
Trial	Task	Presentation time *(seconds)*	Stimulus
10	Task A Dishabituation phase	15	
--		1	-- *white screen (intertrial interval)* --
11	Task A Dishabituation phase	15	
--		2	-- *white screen (intertrial interval)* --
12	Task A Attention control	15	
--		1	-- *white screen (intertrial interval)* --
13	Task A Attention control	15	
--		5	-- *white screen (pause interval)* --
--	Attention getter	3	
14	Task B Habituation phase	10	

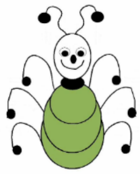
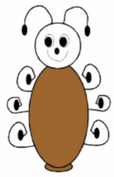
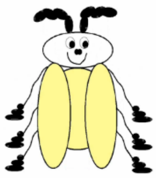
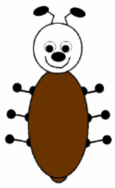
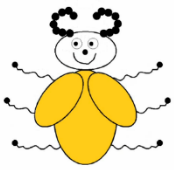
Trial	Task	Presentation time *(seconds)*	Stimulus
--		2	-- *white screen (intertrial interval)* --
15	Task B Habituation phase	10	
--		2	-- *white screen (intertrial interval)* --
16	Task B Habituation phase	10	
--		2	-- *white screen (intertrial interval)* --
17	Task B Habituation phase	10	
--		2	-- *white screen (intertrial interval)* --
18	Task B Habituation phase	10	
--		2	-- *white screen (intertrial interval)* --
19	Task B Habituation phase	10	
--		2	-- *white screen (intertrial interval)* --

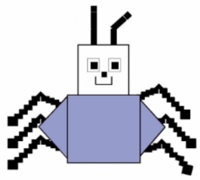
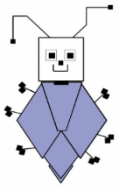
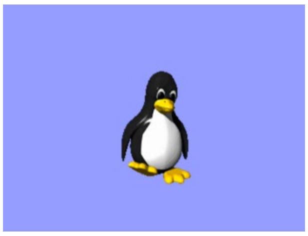
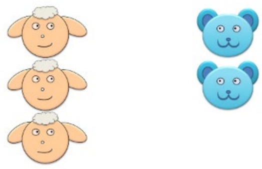
Trial	**Task**	**Presentation time** *(seconds)*	**Stimulus**
20	Task B Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
21	Task B Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
22	Task B Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
23	Task B Dishabituation phase	15	
--		2	*-- white screen (intertrial interval) --*
24	Task B Dishabituation phase	15	
--		2	*-- white screen (intertrial interval) --*

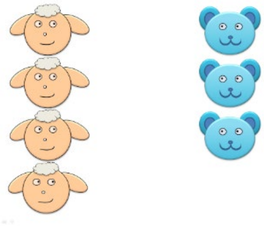
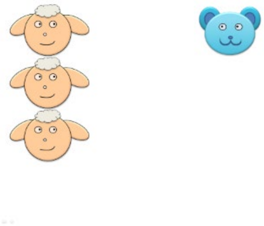
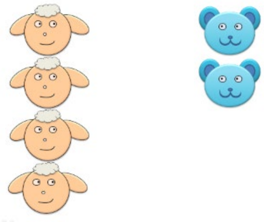
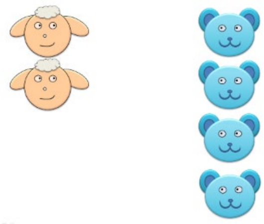
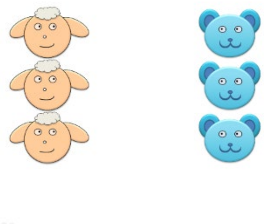
Trial	Task	Presentation time *(seconds)*	Stimulus
25	Task B Attention control	15	
--		2	*-- white screen (intertrial interval) --*
26	Task B Attention control	15	
	End of habituation-dishabituation tasks		

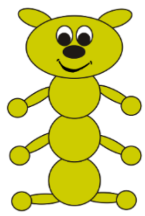
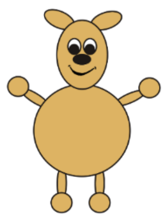
Wave 2: Presentation sequence of the stimulus material

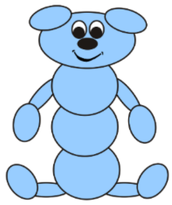
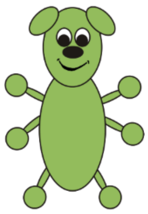
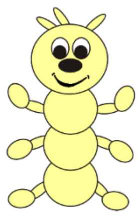
Trial	Task	Presentation time *(seconds)*	Stimulus
--	Attention getter	3	
1	Task C Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
2	Task C Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
3	Task C Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
4	Task C Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*

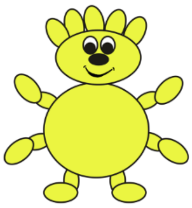
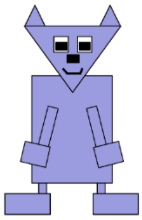
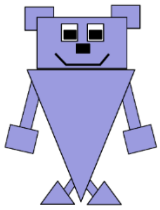
Trial	Task	Presentation time *(seconds)*	Stimulus
5	Task C Habituation phase	10	
--		2	-- *white screen (intertrial interval)* --
6	Task C Habituation phase	10	
--		2	-- *white screen (intertrial interval)* --
7	Task C Habituation phase	10	
--		2	-- *white screen (intertrial interval)* --
8	Task C Habituation phase	10	
--		2	-- *white screen (intertrial interval)* --
9	Task C Habituation phase	10	
--		2	-- *white screen (intertrial interval)* --

Trial	**Task**	**Presentation time** *(seconds)*	**Stimulus**
10	Task C Dishabituation phase	10	
--		2	*-- white screen (intertrial interval) --*
11	Task C Dishabituation phase	10	
--		2	*-- white screen (intertrial interval) --*
12	Task C Attention control	10	
--		2	*-- white screen (intertrial interval) --*
13	Task C Attention control	10	
--		5	*-- white screen (pause interval) --*
--	Attention getter	3	
14	Task D Habituation phase	10	

Trial	Task	Presentation time *(seconds)*	Stimulus
--		2	-- *white screen (intertrial interval)* --
15	Task D Habituation phase	10	
--		2	-- *white screen (intertrial interval)* --
16	Task D Habituation phase	10	
--		2	-- *white screen (intertrial interval)* --
17	Task D Habituation phase	10	
--		2	-- *white screen (intertrial interval)* --
18	Task D Dishabituation phase	10	
--		2	-- *white screen (intertrial interval)* --
19	Task D Dishabituation phase	10	
--		2	-- *white screen (intertrial interval)* --

Trial	Task	Presentation time *(seconds)*	Stimulus
20	Task D Attention control	10	
--		2	-- *white screen (intertrial interval)* --
21	Task D Attention control	10	
--		5	-- *white screen (pause interval)* --
--	Attention getter	3	
22	Task E Habituation phase	10	
--		2	-- *white screen (intertrial interval)* --
23	Task E Habituation phase	10	
--		2	-- *white screen (intertrial interval)* --
24	Task E Habituation phase	10	

Trial	Task	Presentation time *(seconds)*	Stimulus
--		2	*-- white screen (intertrial interval) --*
25	Task E Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
26	Task E Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
27	Task E Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
28	Task E Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
29	Task E Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*

Trial	Task	Presentation time *(seconds)*	Stimulus
30	Task E Habituation phase	10	
--		2	*-- white screen (intertrial interval) --*
31	Task E Dishabituation phase	10	
--		2	*-- white screen (intertrial interval) --*
32	Task E Dishabituation phase	10	
--		2	*-- white screen (intertrial interval) --*
33	Task E Attention control	10	
--		2	*-- white screen (intertrial interval) --*
34	Task E Attention control	10	
End of habituation-dishabituation tasks			

Documentation of the modifications as of April 2023

Date	Page	Modification
April 2023	Page 12	Inserting the footnote