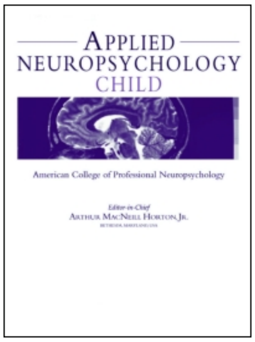

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The association of gender, age, and intelligence with neuropsychological functioning in young typically developing children: The Generation R study

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ABSTRACT

Although early childhood is a period of rapid neurocognitive development, few studies have assessed neuropsychological functioning in various cognitive domains in young typically developing children. Also, results regarding its association with gender and intelligence are mixed. In 853 typically developing children aged 6 to 10 years old, the association of gender, age, and intelligence with neuropsychological functioning in the domains of attention, executive functioning, language, memory, sensorimotor functioning, and visuospatial processing was explored. Clear positive associations with age were observed. In addition, gender differences were found and showed that girls generally outperformed boys, with the exception of visuospatial tasks. Furthermore, IQ was positively associated with neuropsychological functioning, which was strongest in visuospatial tasks. Performance in different neuropsychological domains was associated with age, gender, and intelligence in young typically developing children, and these factors should be taken into account when assessing neuropsychological functioning in clinical or research settings.

KEYWORDS

Children; epidemiology; NEPSY-II-NL; neuropsychology; typical development

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Introduction

Although early childhood is a period of major neurocognitive development (Casey, Tottenham, Liston, & Durston, 2005; Giedd et al., 1999; Gogtay et al., 2004), relatively few studies have focused on neuropsychological functioning in young typically developing children. However, examining children's cognitive abilities during a young age is of great importance, because understanding typical development will also help us to better understand aberrant (cognitive) development in young children. In addition, previous studies have shown mixed results regarding the association of gender and intelligence with neuropsychological functioning. Therefore, the purpose of this study was to evaluate neuropsychological functioning (and specifically age-, gender-, and intelligence-related differences) in a large sample of typically developing children. We focused on a narrow age range of 6 to 10 years and present an overview of neuropsychological functioning during this important period of cognitive development.

Neuropsychological functioning is a broad concept composed of different cognitive functions, including language, memory, executive functioning, visuospatial processing, and sensory and motor functions, which are essential in daily life. These neuropsychological functions have been shown to develop at different ages and to follow different developmental trajectories. For example, simple language functions have been shown to be established at a young age, even before school age, while more complex language functions continue

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Sabine E. Mous and Nikita K. Schoemaker contributed equally.

F. C. V. is head of the Department of Child and Adolescent Psychiatry/Psychology at the Erasmus Medical Center, which publishes the Achenbach System of Empirically Based Assessment and from which he receives remuneration. All other authors report no conflicts of interest.

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to develop throughout adolescence (Korkman, Barron-Linnankoski, & Lahti-Nuuttila, 1999; Korkman, Kemp, & Kirk, 2001; Rosselli, Ardila, Navarrete, & Matute, 2010). Primary motor functions also mature early in development (before the age of 9 years; Del Giudice et al., 2000; Korkman et al., 2001), whereas more complex visuospatial abilities appear to reach mastery at a later age, around the beginning of adolescence (Del Giudice et al., 2000; Korkman, Lahti-Nuuttila, Laasonen, Kemp, & Holdnack, 2013; Rosselli et al., 2010). The finding that simple motor functions develop relatively early in life is in line with findings of brain-imaging studies showing that the primary sensorimotor areas (precentral and postcentral gyrus) are among the first to mature (Casey et al., 2005; Gogtay et al., 2004; Shaw et al., 2008). The prefrontal cortex, on the other hand, matures at a later age and even continues to develop well into adolescence and early adulthood (Giedd et al., 1999). Numerous studies have focused on the development of the executive functions that are mediated by the frontal regions of the brain, such as inhibition, planning, shifting, and working memory. These studies have shown mixed results with respect to the age at which peak performance is reached, dependent on the kind of executive function studied. However, overall, it seems that most complex executive functions continue to develop throughout childhood and into young adulthood (Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001; Huizinga, Dolan, & van der Molen, 2006; Korkman et al., 2013; Rosselli et al., 2010). Finally, it has been shown that most memory functions are still developing into adolescence, although the exact age of mastery varies depending on the type of memory task used and the cognitive load (Huizinga et al., 2006; Korkman et al., 2001, 2013; White, Schmidt, & Karatekin, 2010). Working memory, for example, seems to develop from 2 years to about 12 years of age (Gathercole, 1998, 1999), while long-term memory develops relatively fast from 5 to 8 years of age and then gradually stabilizes (Gathercole, 1998; Schneider, Knopf, & Sodian, 2009).

Many studies have shown gender differences in the performance of specific neuropsychological tasks. Generally, girls outperform boys on language and other verbal tasks, while boys tend to perform better on tasks that require spatial abilities (Levine, Huttenlocher, Taylor, & Langrock, 1999; Linn & Petersen, 1985; Mann, Sasanuma, Sakuma, & Masaki, 1990; Strand, Deary, & Smith, 2006; Voyer, 2011). However, contrasting results have been reported as well (Ardila, Rosselli, Matute, & Inozemtseva, 2011; Strand et al., 2006). Surprisingly, in previous publications, the authors of the developmental NEuroPSYchological assessment second edition (NEPSY-II), the instrument used in our study, have not reported on the relationship between gender and neuropsychological functioning on the NEPSY-II (Korkman et al., 2001, 2013).

Previous studies (mainly in adults or adolescents) have shown various neuropsychological functions to be substantially related to general intelligence (Diaz-Asper, Schretlen, & Pearlson, 2004; Jung, Yeo, Chiulli, Sibbitt, & Brooks, 2000; Seidenberg, Giordani, Berent, & Boll, 1983). However, results are mixed with regard to the strength of the association for different neuropsychological domains, and multiple studies have pointed out that not all different neuropsychological functions can be explained equally well by intelligence. Some studies have shown that measures requiring problem-solving abilities and language skills (Seidenberg et al., 1983) or verbal fluency (Ardila, Pineda, & Rosselli, 2000) are more strongly related to general intelligence than simple perceptual and motor functions (Seidenberg et al., 1983) and executive functions such as response inhibition (Ardila et al., 2000). A study by Friedman et al. (2006), for example, showed intelligence to be strongly related to updating working memory, but not to response inhibition and shifting (Friedman et al., 2006). However, contrasting results have been published as well (Arffa, 2007). Multiple studies have stated that intelligence tests do not measure all different cognitive functions equally well and that neuropsychological instruments sensitive to more specific cognitive (mainly executive) functions are therefore of great importance (Ardila, 1999; Ardila et al., 2000; Friedman et al., 2006).

Aims of the study

Because previous studies have shown mixed results regarding the role of gender and intelligence in neuropsychological functioning and because not many studies have been done in young, typically developing children, the goal of this study was to assess the association of age, gender, and intelligence with neuropsychological functioning on the NEPSY-II-NL (Dutch edition of the NEPSY-II) in a large group ($n = 853$) of typically developing children aged 6 to 10 years old. To better understand aberrant (cognitive) development, it is of great importance that we gain insight into normal development. With respect to age differences, we hypothesized that while most cognitive domains will support ongoing development, simple (visuo)motor functions will be mastered within the age range of our sample. With respect to gender differences, we expected to find that girls outperform boys on language tasks, while boys perform better on tasks requiring visuospatial abilities. With respect to the association between neuropsychological functioning and intelligence, we hypothesized that while performance on most neuropsychological tasks would show a strong association with intelligence, performance on measures of executive functioning (and in particular, response inhibition) would show the weakest association with intelligence in this age group.

Methods and materials

Participants

This study is embedded within the Generation R study, a multiethnic population-based cohort study investigating children's health, growth, and development from fetal life onward in Rotterdam, The Netherlands. An overview of the Generation R study design and population has been previously described (Jaddoe et al., 2012; Tiemeier et al., 2012).

When the children were aged 6 to 10 years old, a detailed neuropsychological assessment was performed in a subgroup of the entire Generation R population, as part of a pilot brain magnetic resonance imaging (MRI) study. Exclusion criteria of this study included contraindications for the MRI procedure (i.e., pacemaker, ferrous metal implants, claustrophobia), severe motor or sensory disorders (deafness or blindness), neurological disorders, and moderate-to-severe head injuries with loss of consciousness (White et al., 2013). From September 2009 to July 2013, a total of 1,325 children were recruited; 1,307 of these children completed the neuropsychological assessment. The neuropsychological assessment was added to the existing research protocol in March 2010, and in addition, some participants arrived late to the research center, resulting in missing neuropsychological data in 18 children.

To focus on neuropsychological functioning in children without behavioral problems, we excluded boys and girls with Child Behavior Checklist (CBCL 1.5–5) scores above the clinical range (syndrome and *Diagnostic and Statistical Manual of Mental Disorders*-oriented scale scores > 98th percentile and broadband scale scores > 91st percentile, according to the guidelines; Achenbach & Rescorla, 2000). This resulted in a final study population of 853 children (Figure 1).

Demographic information such as date of birth, gender, and birth weight was obtained from midwives and hospital registries. Child ethnicity was defined according to the ethnicity categorization of Statistics Netherlands (2004a). Children with both parents born in The Netherlands were considered Dutch, and children were classified as Non-Dutch (further categorized as "Other Western" and "Other Non-Western") if at least one parent was born outside The Netherlands. Information regarding monolingualism or multilingualism of the child was reported by parents using a questionnaire when the child was around 2.5 years of age. CBCL scores were obtained using a questionnaire, filled out by the primary caregiver during the assessment wave at 6 years of age. Parental educational level was defined as highest education completed, according to the definition of Statistics Netherlands (2004b), and household income was defined by the total net monthly income of the household. Information on maternal and paternal psychopathology was obtained through questionnaires when the children were around 3 years of age, using the Brief Symptom Inventory (De Beurs, 2004). With these questionnaires, depression and anxiety symptoms were measured. Based on the Dutch cutoffs (De Beurs, 2009), the percentage of mothers

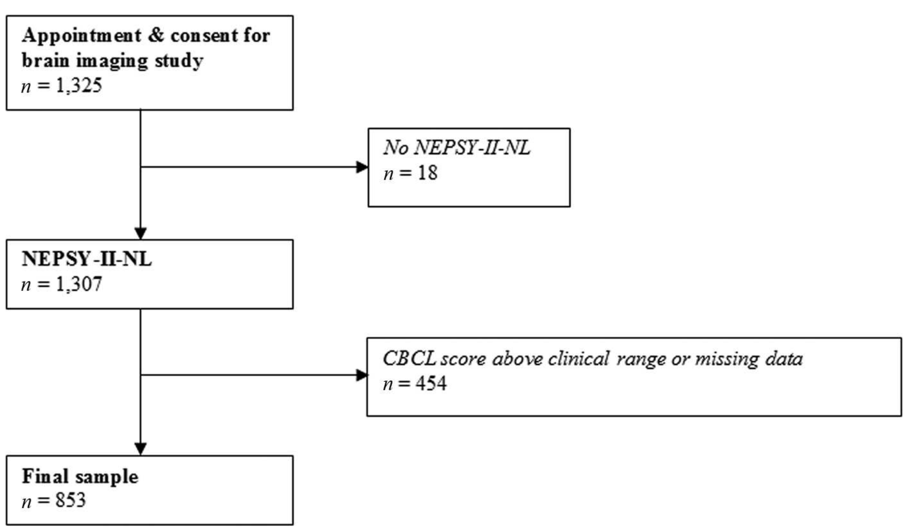

Figure 1. Flowchart participant selection. *Note.* CBCL = Child Behavior Checklist.

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and fathers with clinically significant problems was calculated.

Information on maternal smoking and alcohol use during pregnancy was obtained using questionnaires in each trimester of pregnancy. Cannabis use was assessed by a questionnaire during the first trimester of pregnancy. All child and parental characteristics are shown in Table 1.

Table 1. Child and maternal characteristics ($n = 853$).

	Mean (*SD*)
Child characteristics	
Gender, % boys	51.2
Mean age during NEPSY-II-NL assessment (years;months)	7;1
SON-R nonverbal IQ (score)[a]	104.0 (13.5)
Below average IQ (<90), %	13.7
Average IQ (90–110), %	55.2
Above average IQ (>110), %	31.1
Mean age during SON-R IQ assessment (years;months)[a]	6;1
Ethnicity, %	
Dutch	74.4
Other Western	8.1
Non-Western	17.5
Language, %	
Monolingual (Dutch)	59.8
Multilingual (Dutch + other language)	9.6
Unknown	30.6
Child Behavior Checklist (score)	
Total score	17.5 (11.9)
Internalizing problems	5.0 (3.9)
Externalizing problems	7.0 (5.6)
Birth weight (grams)	3,442.3 (571.6)
Parental characteristics	
Maternal educational level, %	
High	57.9
Medium	30.7
Low	10.1
Unknown	1.3
Paternal educational level, %	
High	53.8
Medium	26.3
Low	11.7
Unknown	8.2
Monthly household income, %	
> €2,000 (USD 2,200)	75.0
€1,200–€2,000 (USD 1,300-2,200)	14.3
< €1,200 (USD 1,300)	4.8
Unknown	5.9
Maternal psychopathology, %	
Depressive symptoms	
No depressive symptoms	67.9
Depressive symptoms	2.7
Unknown	29.4
Anxiety symptoms	
No anxiety symptoms	67.4
Anxiety symptoms	3.2
Unknown	29.4
Paternal psychopathology, %	
Depressive symptoms	
No depressive symptoms	60.0
Depressive symptoms	1.8
Unknown	38.2
Anxiety symptoms	
No anxiety symptoms	57.9
Anxiety symptoms	3.9
Unknown	38.2
Maternal smoking (any), %	
Never during pregnancy	76.1
Until pregnancy was known	7.0
Continued during pregnancy	14.8
Unknown	2.1
Maternal alcohol use (any), %	
Never during pregnancy	32.2
Until pregnancy was known	13.4
Continued occasionally during pregnancy	37.3
Continued frequently during pregnancy[b]	11.5
Unknown	5.6
Maternal cannabis use (any), %	
No cannabis use during pregnancy	87.3
Cannabis use during pregnancy	4.7
Unknown	8.0

Note. Values represent mean (*SD*), unless otherwise indicated. SON-R = Snijders-Oomen Niet-verbale intelligentie Test-Revisie.
[a]*n* with IQ data = 679.
[b]Frequent continued use was defined as one drink or more per week during at least two trimesters of pregnancy.

Neuropsychological functioning

The neuropsychological assessment was performed using the NEPSY-II-NL. The NEPSY-II-NL is an official and validated Dutch translation and adaptation of the North American NEPSY-II (Brooks, Sherman, & Strauss, 2009). Acceptable to good reliability and validity have been reported for the NEPSY-II (Korkman et al., 2010b). The NEPSY-II-NL can be used to assess neuropsychological functioning in 5- to 12-year-old children. To our knowledge, this study is the first using the Dutch NEPSY-II. The full NEPSY-II-NL battery consists of 34 tasks. Due to time constraints, we selected a battery of 10 tasks from the NEPSY-II-NL (White et al., 2013). Each of these 10 tasks falls into five specific NEPSY-II-NL neuropsychological domains: attention and executive functioning, language, memory and learning, sensorimotor functioning, and visuospatial processing. The battery took approximately 55 min to administer, and the children were randomly assigned to receive one of four selected orders of task administration. Because a small (pilot) subgroup of our population was offered a shorter battery of only 6 NEPSY-II-NL tasks (instead of 10), a somewhat smaller sample size was available for 4 tasks (Statue, Narrative Memory, Geometric Puzzles, and Route Finding).

Rules from the manual of the NEPSY-II-NL were closely followed (Korkman, Kirk, & Kemp, 2010a). These rules described start procedures (e.g., older children may start with different items than younger children) and stop procedures (e.g., after five subsequent scores of 0, a certain task may be stopped). However, to fully explore age effects, we did not follow age-related stop procedures (in the official rules, younger children were sometimes allowed to stop a task earlier than older children). Finally, in the individual analyses of each NEPSY-II-NL task, children with incomplete or unreliable (as observed by the test assistant) data (e.g., due to time constraints, lack of cooperation, refusal, or an inability to understand the instructions) were excluded.

Attention and executive functioning

Multiple interrelated processes define the neuropsychological constructs of attention and executive functions. We used two different tasks from the attention and

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executive-functioning domain of the NEPSY-II-NL. The first task was the Auditory Attention and Response Set task, which consists of two parts. The Auditory Attention component was administered first and measures selective and sustained attention. Selective attention refers to the ability to focus on a specific task while suppressing irrelevant stimuli. Sustained attention refers to the ability to attend to a task for a long(er) period of time. In the Auditory Attention task, the children were presented with recordings of a long list of color words and other words and were asked to only respond to the word "red" by touching the red circle on the sheet in front of them. The sheet also contained a blue, black, and yellow circle, but these circles had to be ignored. Touching the red circle within 2 s indicated a correct response.

Following the Auditory Attention component, Response Set was performed. This task taps into response inhibition and working memory. Inhibition is the ability to suppress (automatic) behavior. Working memory is required to keep information actively in mind for as long as needed to complete a task. In this task, children must respond to the word "red" by touching the yellow circle, respond to "yellow" by touching the red circle, and lastly, respond to the word "blue" by touching the blue circle. All of the other colors or words should be ignored. Touching the correct circle within 2 s indicates a correct response. Touching another color is incorrect, as is having a delayed response (not within a 2-s interval). Even though children younger than 7 years of age should stop after the first task (i.e., Auditory Attention) according to the NEPSY-II-NL manual (Korkman et al., 2010a), Response Set was assessed in all participants, including the 6-year-old children. From the Auditory Attention and Response Set task, various summary scores were calculated. These scores included the total correct responses and the total number of commission, omission, and inhibition errors.

The second task in the domain of attention and executive functioning is the Statue task. This task requires a child to maintain a "statue-like" body position for a period of 75 s, while at the same time ignoring environmental distractors. This task measures motor persistence and response inhibition during 15 intervals of 5 s each. Summary measures from the Statue task include the total number of body movements, eye openings, and sound productions, as well as a total score. According to the NEPSY-II-NL manual, this task is only suitable for children up to and including 6 years of age (Korkman et al., 2010b). Therefore, we performed the analyses only in children aged 6 old to prevent a ceiling effect.

Language

The language skills domain involved a test of verbal fluency, the Word Generation task. This task measures how many words a child can generate within 60 s in two semantic categories. In the first category, children have to name as many animals as possible, and in the second category, they have to name food and drinks. The total semantic score is the sum of the total number of correctly generated words for both categories together. Correct words include existing words, are not proper nouns, and have not been mentioned before by the child (no repetitions).

Memory and learning

The memory and learning domain included a task on immediate and delayed memory for faces and a verbal memory task. During the Memory for Faces task, the child was first presented with multiple series of three faces and was asked to look closely at each face (for 5 s). The child was then provided with another set of three faces and was asked which face he or she had seen before. Immediate recall is the skill to retrieve information from memory immediately after learning. The delayed recall version of this task was assessed after a delay period of 15 min to 25 min and measured the ability to retrieve information after a longer period of time. All presented faces showed a neutral expression. A total correct score was calculated for both the immediate and delayed recall.

We used the Narrative Memory task to assess verbal memory, specifically immediate free recall, cued recall, and (passive) recognition of verbal information. In this task, children listened to a short story after which the child was asked to provide as many details about the story as he or she could remember. This free recall component of the task measures the child's ability to remember and actively recall the story. Subsequently, children were asked specific questions about the story (cued recall), and finally, they were asked questions that only required yes and no answers and/or multiple-choice questions (recognition). The Narrative Memory task provides a total correct score for the free and cued recall combined, the free recall only, and recognition.

Sensorimotor functioning

To gain motor control, one has to be able to combine motor activity and sensory feedback. For example, visuomotor accuracy requires visual input and motor output. During the paper-and-pencil task of Visuomotor Precision, the child draws a line with the dominant hand as quickly and as accurately as possible along a paper path. The paper path consists of a set of parallel curved lines, and the child is asked to draw a line, as quickly and with as few errors as possible, in between the two lines. Summary scores for the Visuomotor Precision task include the total completion time, total number of errors

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(i.e., drawing outside the lines of the path), and the total number of times that the child lifted the pencil. These summary scores tap into both the speed and accuracy of visuomotor performance.

Visuospatial processing

Visuospatial processing refers to the neuropsychological constructs of visual perception and spatial processing. Matching visual patterns and identifying figures within a picture are examples of visual perception skills, whereas mental rotation and judging orientation and direction are examples of spatial-processing skills. The visuospatial-processing domain consisted of three different tasks.

The Arrows task measured the child's ability to judge the direction of an arrow by asking the child to select, out of multiple arrows, the correct arrow(s) that point (s) to center of a target. The summary score for the Arrows task is the total number of correct responses.

The Geometric Puzzles task measured mental rotation, visuospatial working memory, and attention to detail. This task requires a child to discriminate which abstract figures in a set match those within a grid containing multiple abstract figures. Figures on the grid can be rotated and thus may not be exactly the same as the example figure. Even though the NEPSY-II-NL manual states that children aged 6 years or younger should stop after completion of 12 items (Korkman et al., 2010a), the whole task (of 20 items) was assessed in all participants, regardless of age.

Finally, we administered the Route Finding task, which measures visuospatial relations, orientation, and direction. The child uses a skeleton map showing a specific route to a house and needs to translate this route onto a map containing houses and side streets. The maps progress from simple to complex. The summary score obtained from this task is the total correct score from a series of 10 maps.

Intelligence

IQ of the child was assessed when children were aged 5 to 8 years old, using a shortened version of the Snijders-Oomen Niet-verbale intelligentie Test-Revisie (SON-R 2.5–7). The SON-R 2.5–7 is a nonverbal intelligence test suited for children aged 2.5 years to 7 years old. Good reliability and validity have been reported, and the total IQ scores of the SON-R 2.5–7 have been found to correlate strongly ($r = .60$–$.83$) with performance IQ on the Wechsler Preschool and Primary Scale of Intelligence (Moore, O'Keefe, Lawhon, & Tellegen, 1998; Tellegen, Winkel, Wijnberg-Williams, & Laros, 2005). Two subtests were performed: Mosaics, a performance subtest that assesses spatial insight, and Categories, a reasoning subtest that assesses abstract-reasoning abilities. More detailed information regarding the SON-R assessment has been described earlier (Basten et al., 2014). Because the NEPSY-II-NL data and data on intelligence were collected during different study visits, IQ data were available in only 679 of the 853 children in total. Nonresponse analyses comparing the children with and without IQ data on the demographic variables described in Table 1 did not reveal any differences.

Statistical analyses

To analyze the association of gender with the NEPSY-II-NL scores, we performed two-way analyses of covariance (ANCOVA). To assess the association of age and intelligence with neuropsychological functioning, we performed linear regression analyses. Analyses of age differences were adjusted for ethnicity and gender, analyses on gender were adjusted for ethnicity and age, and analyses on intelligence were adjusted for ethnicity, age, and gender.

In the analyses of age differences, we also tested a model with a quadratic age term (age in years squared) to explore potential nonlinear age associations and to assess potential plateau effects in performance, which could represent the age of mastery of a certain neuropsychological function. If a nonlinear age association was found, effect estimates (both the linear and quadratic) of the quadratic model (that included the squared term) were provided in the text and in Table 2. If there was no nonlinear effect, the effect estimate of the linear model was provided. For ease of interpretation and visualization and to examine whether and in which age range mastery took place, we additionally examined age in seven age groups in relation to neuropsychological performance. We used the oldest age group as a reference category in these analyses (Figure 3).

For summary scores that were not normally distributed, we applied either square root (Response Set commission and omission errors, Visuomotor Precision total time, Arrows) or log (Auditory Attention all scores, Response Set total score and inhibition errors, Statue all scores, Narrative Memory recognition, Visuomotor Precision errors and pencil lifts, Route Finding) transformations to approach a normal distribution.

To correct for multiple testing, Bonferroni correction was applied. Because of the considerable intercorrelations between the different NEPSY-II-NL scores, we first calculated the effective number of tests and

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Table 2. The association of age with NEPSY-II-NL task performance.

Task	n	Age[a]	Age squared[a]
Attention and executive functioning			
Auditory Attention			
Total score[b]	834	**$\beta = .18$, $p < .0001$, $pr = .18$**	*ns*
Commission errors[b]	834	**$\beta = -.24$, $p < .0001$, $pr = -.24$**	$\beta = .08$, $p = .026$, $pr = .08$
Omission errors[b]	834	**$\beta = -.34$, $p < .0001$, $pr = -.34$**	*ns*
Inhibition errors[b]	834	$\beta = -.07$, $p = .046$, $pr = -.07$	*ns*
Response Set			
Total score[b]	829	**$\beta = .37$, $p < .0001$, $pr = .36$**	**$\beta = -.12$, $p < .0001$, $pr = -.13$**
Commission errors[b]	829	**$\beta = -.34$, $p < .0001$, $pr = -.34$**	$\beta = .08$, $p = .011$, $pr = .09$
Omission errors[b]	829	**$\beta = -.38$, $p < .0001$, $pr = -.38$**	$\beta = .09$, $p = .007$, $pr = .09$
Inhibition errors[b]	829	**$\beta = -.30$, $p < .0001$, $pr = -.29$**	**$\beta = .11$, $p = .002$, $pr = .11$**
Statue[cd]			
Total score[b]	187	*ns*	*ns*
Total movements[b]	187	*ns*	*ns*
Total sounds[b]	187	$\beta = .15$, $p = .036$, $pr = .16$	*ns*
Total eye openings[b]	187	*ns*	*ns*
Language			
Word Generation			
Total semantic score	803	**$\beta = .47$, $p < .0001$, $pr = .48$**	*ns*
Memory and learning			
Memory for Faces			
Total score	845	**$\beta = .23$, $p < .0001$, $pr = .22$**	*ns*
Memory for Faces—delayed			
Total score	838	**$\beta = .26$, $p < .0001$, $pr = .26$**	*ns*
Narrative Memory[c]			
Total score free and cued recall	652	**$\beta = .38$, $p < .0001$, $pr = .38$**	*ns*
Total score free recall	652	**$\beta = .40$, $p < .0001$, $pr = .40$**	*ns*
Total score recognition[b]	662	**$\beta = .18$, $p < .0001$, $pr = .18$**	*ns*
Sensorimotor function			
Visuomotor Precision			
Total time[b]	835	**$\beta = -.20$, $p < .0001$, $pr = -.20$**	*ns*
Total errors[b]	835	**$\beta = -.27$, $p < .0001$, $pr = -.27$**	$\beta = .09$, $p = .008$, $pr = .09$
Total pencil lifts[b]	835	**$\beta = -.12$, $p = .001$, $pr = -.12$**	*ns*
Visuospatial processing			
Arrows			
Total score[b]	840	**$\beta = .36$, $p < .0001$, $pr = .37$**	$\beta = -.09$, $p = .007$, $pr = -.09$
Geometric Puzzles[c]			
Total score	701	**$\beta = .35$, $p < .0001$, $pr = .35$**	*ns*
Route Finding[c]			
Total score[b]	646	**$\beta = .36$, $p < .0001$, $pr = .37$**	**$\beta = -.13$, $p < .0001$, $pr = -.15$**

Note. Regression analyses were performed. All analyses are adjusted for child ethnicity and gender. Standardized regression coefficients (β) and effect sizes (partial correlations; *pr*) are provided. Multiple testing corrected significance level set at $\alpha = .003$. **Bold** results survived correction for multiple testing.
[a]In the case of the presence of a nonlinear age association, effect estimates (linear and quadratic) of the quadratic model are provided. If there was no nonlinear effect, the effect estimate of the linear model is provided.
[b]Mathematically transformed score was used.
[c]Not assessed in the shortened NEPSY-II-NL battery that was administered in a subgroup of the participants.
[d]Analyses performed only in 6-year-old children.

adjusted the Bonferroni correction accordingly to account for this lack of independence (Galwey, 2009). The calculation yielded an effective number of 18.56 tests, which resulted in a corrected significance threshold of $\alpha = 0.05/18.56 = .003$.

All analyses were performed using the Statistical Package for the Social Sciences Statistics Version 21.

Results

For all neuropsychological tasks, the results of the analyses of age associations are shown in Table 2. Furthermore, mean test scores per age category can be found in supplemental Table S1. Table 3 provides the results of the analyses regarding gender differences. In addition, Figure 2 provides a visual representation of the effect of gender and age on neuropsychological functioning. In Figure 3, nonlinear age associations are depicted. For the association between intelligence and neuropsychological functioning, the results of the regression analyses are summarized in Table 4. When the analyses were additionally adjusted for maternal smoking and alcohol use during pregnancy, all results remained similar. To be able to assess the strength of the associations, effect sizes are provided in the tables. For the linear regression analyses on age and intelligence, partial correlations (adjusted for the covariates) are provided. For the ANCOVAs regarding gender, Cohen's *d* (Cohen, 1988) is provided (calculated using estimated marginal means and thus also adjusted for the covariates). The effect sizes show that intelligence and gender effects can be regarded as small to medium, while age effects can be regarded as medium to large.

Table 3. The association of gender with NEPSY-II-NL task performance.

Task	n	Gender
Attention and executive functioning		
Auditory Attention		
Total score[a]	834	*ns*
Commission errors[a]	834	**$F(1, 829) = 12.74$, $p < .0001$, $d = 0.20$**
Omission errors[a]	834	$F(1, 829) = 8.00$, $p = .005$, $d = 0.16$
Inhibition errors[a]	834	*ns*
Response Set		
Total score[a]	829	**$F(1, 824) = 16.37$, $p < .0001$, $d = -0.22$**
Commission errors[a]	829	**$F(1, 824) = 30.39$, $p < .0001$, $d = 0.30$**
Omission errors[a]	829	**$F(1, 824) = 22.60$, $p < .0001$, $d = 0.26$**
Inhibition errors[a]	829	**$F(1, 824) = 12.38$, $p < .0001$, $d = 0.20$**
Statue[b,c]		
Total score[a]	187	$F(1, 182) = 3.97$, $p = .048$, $d = -0.24$
Total movements[a]	187	$F(1, 182) = 4.64$, $p = .032$, $d = 0.26$
Total sounds[a]	187	*ns*
Total eye openings[a]	187	*ns*
Language		
Word Generation		
Total semantic score	803	$F(1, 798) = 4.19$, $p = .041$, $d = -0.11$
Memory and learning		
Memory for Faces		
Total score	845	*ns*
Memory for Faces—delayed		
Total score	838	$F(1, 833) = 4.14$, $p = .042$, $d = -0.11$
Narrative Memory[b]		
Total score free and cued recall	652	**$F(1, 647) = 13.86$, $p < .0001$, $d = -0.25$**
Total score free recall	652	**$F(1, 647) = 14.89$, $p < .0001$, $d = -0.26$**
Total score recognition[a]	662	$F(1, 657) = 6.96$, $p = .009$, $d = -0.18$
Sensorimotor function		
Visuomotor Precision		
Total time[a]	835	*ns*
Total errors[a]	835	**$F(1, 830) = 30.26$, $p < .0001$, $d = 0.30$**
Total pencil lifts[a]	835	**$F(1, 830) = 9.22$, $p = .002$, $d = -0.17$**
Visuospatial processing		
Arrows		
Total score[a]	840	**$F(1, 835) = 31.26$, $p < .0001$, $d = 0.31$**
Geometric Puzzles[b]		
Total score	701	*ns*
Route Finding[b]		
Total score[a]	646	$F(1, 641) = 6.08$, $p = .014$, $d = 0.16$

Note. Analysis of covariance was used. All analyses are adjusted for child ethnicity and age. Standardized regression coefficients (β) and effect sizes (Cohen's *d*) are provided. Multiple testing corrected significance level set at $\alpha = .003$. **Bold** results survived correction for multiple testing.
[a]Mathematically transformed score was used.
[b]Not assessed in the shortened NEPSY-II-NL battery that was administered in a subgroup of the participants.
[c]Analyses performed only in 6-year-old children.

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Attention and executive functioning

A total of 834 children completed the Auditory Attention task. After correction for multiple testing, the analyses showed that older children had a higher total score than younger children ($\beta = .18$, $p < .0001$). Older children also made fewer commission ($\beta = -.24$, $p < .0001$) and omission ($\beta = -.34$, $p < .0001$) errors (Table 2). With respect to gender, we found that girls made fewer commission errors than boys, $F(1, 829) = 12.74$, $p < .0001$ (Table 3). A total of 666 children with data on intelligence completed the Auditory Attention task. After correction for multiple testing, we found no significant associations between functioning on this task and IQ (Table 4).

A total of 829 children successfully completed the Response Set task. After correction for multiple testing, the analyses showed that older children had a significantly higher total score than younger children. In addition, older children made fewer commission, omission, and inhibition errors (all $p < .0001$; Table 2). For the total score and the number of inhibition errors on the Response Set task, we also found a significant nonlinear association with age, potentially indicating a plateau effect of performance. For the total score ($\beta = -.12$, $p < .0001$), performance remained relatively stable from 8.5 years to 9 years of age onward. The number of inhibition errors ($\beta = .11$, $p = .002$) already remained relatively stable from 8 years to 8.5 years of age onward (Figure 3). Regarding gender, we found that girls had a significantly higher total score than boys, $F(1, 824) = 16.37$, $p < .0001$. Analyses on the amount of commission, omission, and inhibition errors also showed that girls made significantly fewer errors compared with boys (all $p < .0001$; Table 3). A total of 662 children with data on intelligence successfully

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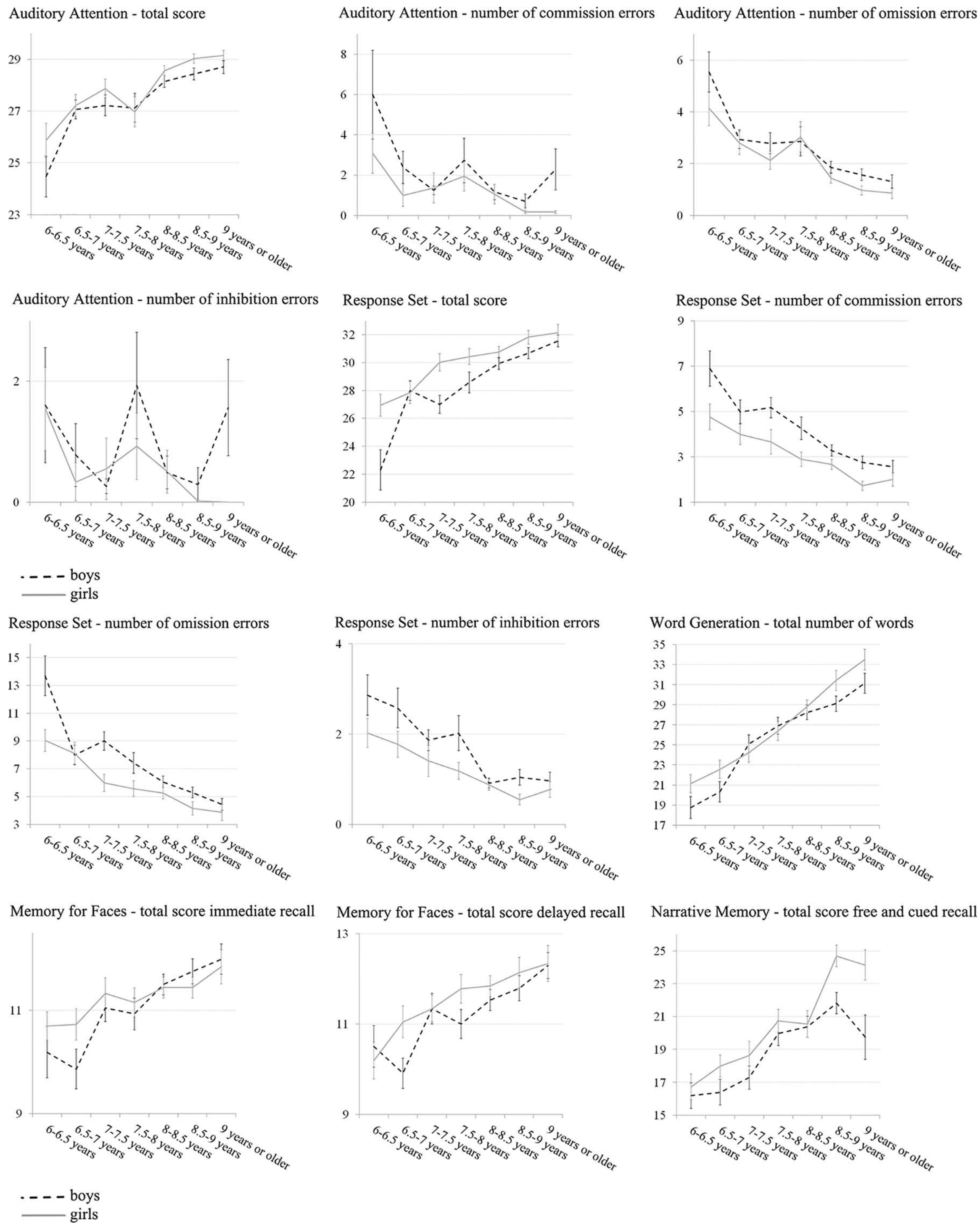

Figure 2. Gender- and age-related trajectories in NEPSY-II-NL. (Unadjusted) mean scores and standard errors are presented. The exact number of children per age category depicted differs per task, but proportions were roughly 9% (6–6.5 years), 13% (6.5–7 years), 13% (7–7.5 years), 15% (7.5–8 years), 24% (8–8.5 years), 15% (8.5–9 years), and 11% (9 years and older).

completed the Response Set task. No significant associations were found between functioning on this task and IQ when taking multiple testing into account (Table 4).

The Statue task was successfully completed in 187 6-year-old children. After correction for multiple testing, we found no significant effect of age on any of the scores (Table 2). With respect to gender, we also found no significant differences after correction for multiple testing (Table 3). Data on the Statue task were available in 147 6-year-old children with IQ data. No significant associations with IQ were found after correction for multiple testing (Table 4).

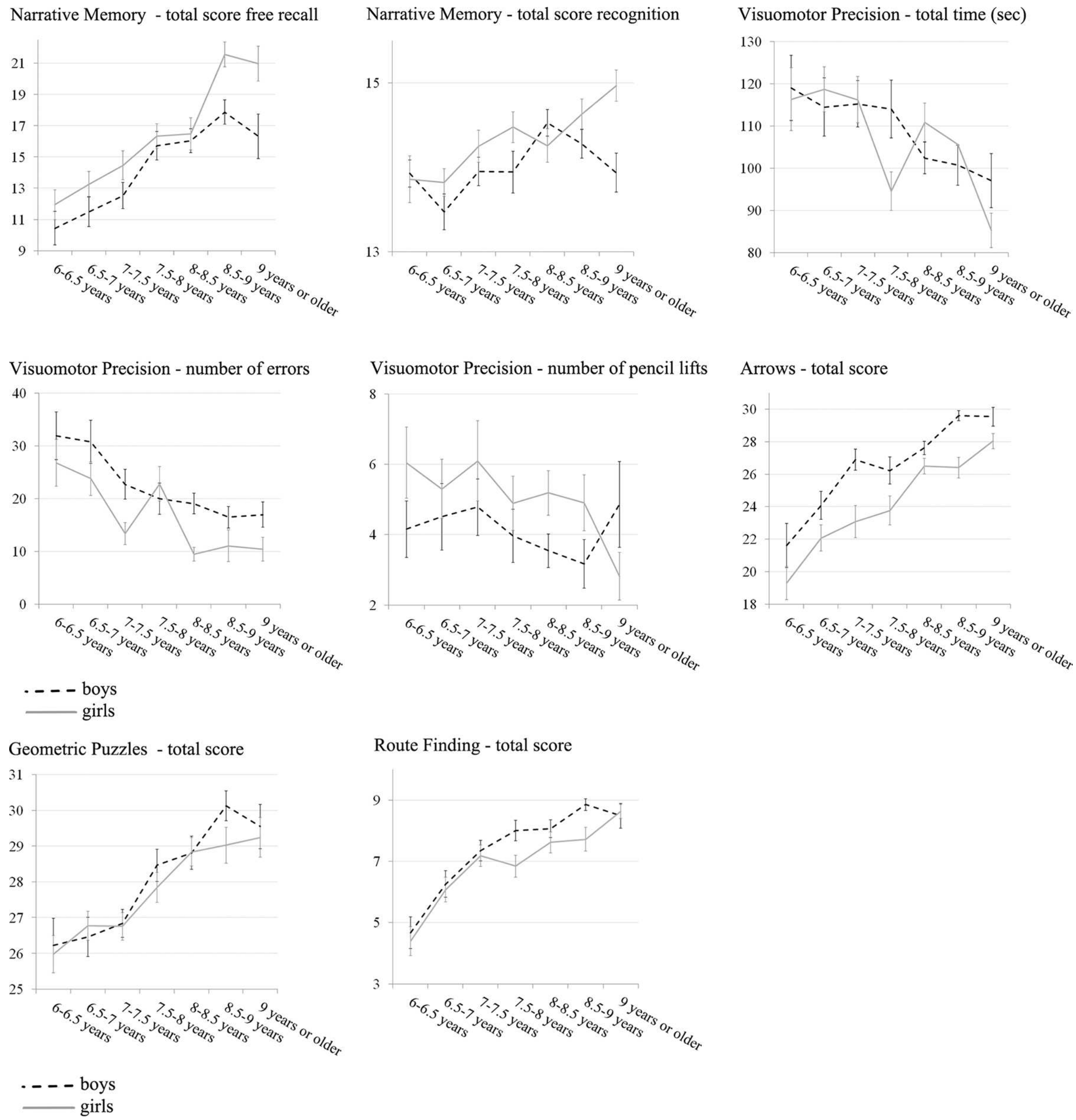

Figure 2. Continued.

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Language

Data on the Word Generation task were complete for 803 children. The analysis showed that older children had better performance on this task than younger children ($\beta = .47$, $p < .0001$; Table 2). After correction for multiple testing, no significant differences were found between boys and girls (Table 3). A total of 638 children with data on IQ completed the Word Generation task. The results of the analysis showed that children with a higher IQ were able to generate significantly more words ($\beta = .11$, $p = .001$; Table 4).

Memory and learning

A total of 845 children completed the Memory for Faces task. The delayed recall part was completed by 838 children. The results showed that older children scored significantly higher on both the immediate and delayed recall ($\beta = .23$, $p < .0001$, and $\beta = .26$, $p < .0001$, respectively; Table 2). When corrected for multiple testing, no differences between boys and girls were found (Table 3). We had complete data on the Memory for Faces task and intelligence in 674 children. The delayed recall part of the task was complete in 668 children with IQ data. When taking multiple testing into account, we found no significant associations with intelligence (Table 4).

The verbal memory task, Narrative Memory, was completed by 652 children, and the recognition part of this task was completed by 662 children. After correction for multiple testing, we found that older children

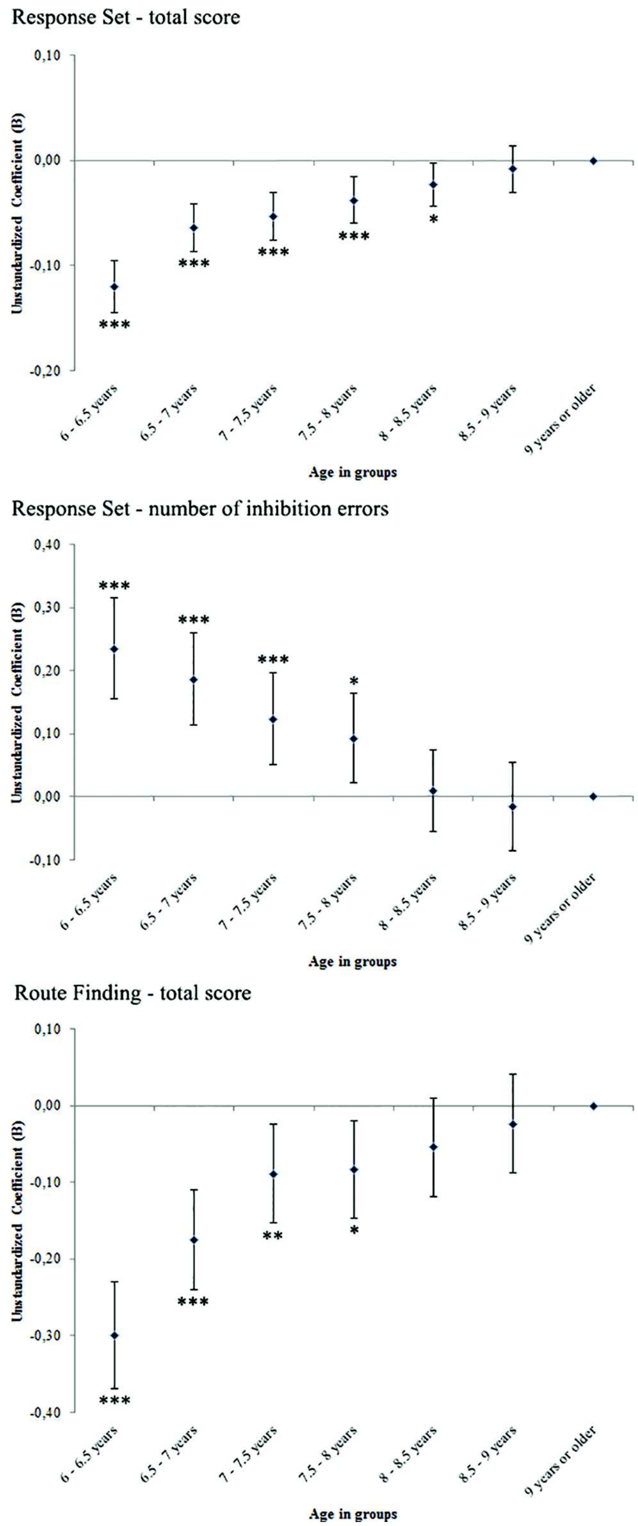

Figure 3. Illustration of nonlinear age associations. Presented are unstandardized regression coefficients (*B*s) and confidence intervals, with the oldest age group used as the reference category. Analyses were adjusted for child gender and ethnicity. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

had higher scores for the combined free and cued recall score ($\beta = .38$, $p < .0001$), the free recall-only score ($\beta = .40$, $p < .0001$), and the recognition score ($\beta = .18$, $p < .0001$; Table 2). With respect to gender differences, we found that girls showed a better performance on the free and cued recall combined, $F(1, 647) = 13.86$, $p < .0001$, and the free recall only, $F(1, 647) = 14.89$, $p < .0001$; Table 3). A total of 521 children with data on IQ completed the Narrative Memory task. The recognition part of the task was completed by 530 children. The results of the analyses showed that children with a higher IQ performed better on combined free and cued recall, free recall only, and recognition ($\beta = .16$, $p < .0001$, $\beta = .14$, $p = .001$, and $\beta = .16$, $p < .0001$, respectively; Table 4).

Sensorimotor functioning

Complete data on the Visuomotor Precision task were available in 835 children. Evaluating the total time necessary to complete the two items ("car" and "motorcycle"), we found that younger children were slower than older children ($\beta = -.20$, $p < .0001$) and made more errors ($\beta = -.27$, $p < .0001$). Finally, older children lifted their pencil significantly less often than younger children ($\beta = -.12$, $p = .001$; Table 2). With respect to gender, we found boys made more errors than girls, $F(1, 830) = 30.26$, $p < .0001$, and girls lifted their pencil significantly more often compared with boys, $F(1, 830) = 9.22$, $p = .002$ (Table 3). Because some children were extremely quick or slow or made a large amount of errors, we performed additional analyses excluding all children ± 2 standard deviations of the group mean for the total completion time and the amount of errors. Data for these 746 children showed the same findings. Complete data on the Visuomotor Precision task and intelligence were available in 664 children. We found an association between IQ and both the total time needed to complete the task ($\beta = .13$, $p = .001$) and the number of errors made ($\beta = -.16$, $p < .0001$). A higher IQ was associated with a longer completion time and fewer errors (Table 4).

Visuospatial processing

A total of 840 children completed the Arrows task. After correction for multiple testing, results showed that older children performed this task better than younger children ($\beta = .36$, $p < .0001$; Table 2). With respect to gender, we found that boys performed better than the girls, $F(1, 835) = 31.26$, $p < .0001$ (Table 3). A total of 670 children with intelligence data completed the Arrows task. Results showed that children with a higher IQ performed significantly better ($\beta = .16$, $p < .0001$; Table 4).

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Table 4. The association of intelligence with NEPSY-II-NL task performance.

Task	n	Intelligence
Attention and executive functioning		
Auditory Attention		
Total score[a]	666	$\beta = .08$, $p = .040$, $pr = .08$
Commission errors[a]	666	*ns*
Omission errors[a]	666	$\beta = -.09$, $p = .020$, $pr = -.09$
Inhibition errors[a]	666	$\beta = -.08$, $p = .044$, $pr = -.08$
Response Set		
Total score[a]	662	$\beta = .08$, $p = .038$, $pr = .08$
Commission errors[a]	662	$\beta = -.09$, $p = .014$, $pr = -.10$
Omission errors[a]	662	$\beta = -.09$, $p = .020$, $pr = -.09$
Inhibition errors[a]	662	*ns*
Statue[b,c]		
Total score[a]	147	*ns*
Total movements[a]	147	*ns*
Total sounds[a]	147	*ns*
Total eye openings[a]	147	$\beta = -.17$, $p = .045$, $pr = -.17$
Language		
Word Generation		
Total semantic score	638	**$\beta = .11$, $p = .001$, $pr = .13$**
Memory and learning		
Memory for Faces		
Total score	674	$\beta = .10$, $p = .007$, $pr = .11$
Memory for Faces—delayed		
Total score	668	*ns*
Narrative Memory[b]		
Total score free and cued recall	521	**$\beta = .16$, $p < .0001$, $pr = .18$**
Total score free recall	521	**$\beta = .14$, $p = .001$, $pr = .15$**
Total score recognition[a]	530	**$\beta = .16$, $p < .0001$, $pr = .16$**
Sensorimotor function		
Visuomotor Precision		
Total time[a]	664	**$\beta = .13$, $p = .001$, $pr = .13$**
Total errors[a]	664	**$\beta = -.16$, $p < .0001$, $pr = -.16$**
Total pencil lifts[a]	664	*ns*
Visuospatial processing		
Arrows		
Total score[a]	670	**$\beta = .16$, $p < .0001$, $pr = .17$**
Geometric Puzzles[b]		
Total score	561	**$\beta = .30$, $p < .0001$, $pr = .32$**
Route Finding[b]		
Total score[a]	519	**$\beta = .27$, $p < .0001$, $pr = .29$**

Note. Regression analyses were performed. All analyses are adjusted for child age, gender, and ethnicity. Standardized regression coefficients (β) and effect sizes (partial correlations; *pr*) are provided. Total *n* with IQ data = 679. Multiple testing corrected significance level set at $\alpha = .003$. **Bold** results survived correction for multiple testing.
[a]Mathematically transformed score was used.
[b]Not assessed in the shortened NEPSY-II-NL battery that was administered in a subgroup of the participants.
[c]Analyses performed only in 6-year-old children.

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The Geometric Puzzles task was completed by 701 children. Older children had a significantly better performance than younger children on this task ($\beta = .35$, $p < .0001$; Table 2). No significant differences were found between boys and girls (Table 3). Data on the Geometric Puzzles task was complete in 561 children with IQ data. We found a strong positive association between performance on this task and intelligence ($\beta = .30$, $p < .0001$; Table 4).

A total of 646 children successfully completed the Route Finding task. The results showed that older children performed better than younger children (Table 2). This age association was nonlinear ($\beta = -.13$, $p < .0001$), potentially indicating a plateau effect of performance with age as performance on the task remained relatively stable from 8 years to 8.5 years onward (Figure 3). After correction for multiple testing, no differences were found between boys and girls (Table 3). Finally, the Route Finding task was successfully collected in 519 children with IQ data. Again, the analysis showed that children with a higher IQ performed significantly better on this task ($\beta = .27$, $p < .0001$; Table 4).

Discussion

In this study, we performed an extensive neuropsychological assessment in a large group ($n = 853$) of young typically developing children, using the NEPSY-II-NL (Brooks et al., 2009). Different domains of neuropsychological development were assessed (i.e., attention and executive functioning, language, memory, sensorimotor functioning, and visuospatial processing). Associations of gender, age, and intelligence with performance were studied.

First, our results showed an effect of gender on performance for the majority of the assessed tasks in

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this age range. On most tasks, girls performed better compared with boys. However, as hypothesized, boys outperformed girls on the visuospatial-processing domain. Previous research has shown that boys tend to perform better than girls on tasks requiring visuospatial abilities (like visuospatial perception and orientation; Linn & Petersen, 1985; Voyer, 2011). The basis of this gender difference in visuospatial abilities is unclear. It may be due to neurobiological differences, such as differences in white-matter development between boys and girls (De Bellis et al., 2001), but it may also be attributable to different experiences of boys and girls that are important for the acquisition, selection, and use of strategies in visuospatial processing (Linn & Petersen, 1985). Our hypothesized gender difference in favor of girls on language tasks was also visible; in the Word Generation task, we found that girls were able to generate more words compared with boys. However, after correction for multiple testing, this difference was only regarded at the trend level.

Interestingly, we are the first to assess gender differences on neuropsychological functioning measured with the NEPSY test battery in typically developing children. Previous normative developmental studies on both the original NEPSY (Korkman et al., 2001) and the NEPSY-II (Korkman et al., 2013) have not addressed gender differences, and no previous studies using the NEPSY-II-NL exist. In addition, the NEPSY-II norm/percentile score conversion tables do not discriminate between boys and girls (Korkman et al., 2010b). Although the differences between boys and girls were only moderate and not as evident and consistent for some tasks as for others, we feel that gender differences should be taken into account when using the NEPSY-II-NL in both clinical practice and for research purposes. Based on our findings and the current knowledge that boys and girls differ in their (neuro)cognitive development, it might even be advisable to create separate norm/percentile conversion tables for boys and girls.

Not unexpectedly, we found that on nearly all tasks, performance was strongly age-dependent, in the sense that older children performed better than younger children. Even though our study sample covered a small age range, considerable age-related differences were evident. These findings are in line with previous studies showing the early school-age period of a child's life to be a period of rapid neurocognitive development (Casey et al., 2005; Giedd et al., 1999; Gogtay et al., 2004). They are also in line with previous studies on the NEPSY and NEPSY-II (Korkman et al., 2001, 2013) that have shown age effects were most pronounced at 5 to 10 years of age.

By repeating the analyses with a quadratic age term included in the model, we were able to examine potential nonlinear age effects that might indicate a plateau effect of performance with age. For only a small number of tasks, we found nonlinear associations with age, indicating that the majority of the cognitive functions that were assessed were still developing during the age range of our study. Only the nonlinear associations of the total score and the number of inhibition errors of the Response Set task and the Route Finding task survived correction for multiple testing. The analyses did show that development seems to go fastest in the youngest children for some of the tasks. Our hypothesis that simple (visuo)motor functions would be mastered in the age range of our sample was somewhat supported by our data because the amount of errors of the Visuomotor Precision task showed a nonlinear association with age. However, this effect did not survive correction for multiple testing, and the time needed to complete the task and the number of pencil lifts, which are also measures of motor development, did not reach a plateau, suggesting continued development. We also found that one visuospatial task (Route Finding) showed a nonlinear age effect in the age range of our study. Previous studies have shown that visuospatial abilities appear to only reach mastery around the beginning of adolescence (Del Giudice et al., 2000; Korkman et al., 2013; Rosselli et al., 2010). And indeed, when looking at Figure 3, it seems that (although the older age groups did not differ significantly from the oldest age group), performance on these tasks is still increasing, but at a slower rate. This finding might mean that peak performance has not been reached yet. This continued development is also supported by the nonsignificant nonlinear associations on the other two visuospatial tasks.

On the Statue task, the influence of age was not apparent. However, this finding is likely because of the small age range for which this task is suitable, and one would not expect a large amount of development in such a small age range. The nonsignificant findings may also be attributable to the relatively small sample, providing insufficient power to detect such small differences. One of the most complex tasks of our test battery in terms of interpretation was the Visuomotor Precision task. Due to the speed/performance trade-off, the analyses were less straightforward. During the assessment, we noticed that the choice of strategy differed between children, because some children tried to be as fast as possible (and paid less attention to the amount of errors), while other children tried to make as few mistakes as possible (and paid less attention to their speed). We did not find any gender-related differences for the amount of time it took to complete the two items, but we did find that girls were more accurate during the

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task because they made fewer errors, although they lifted their pencil more often than boys. As expected, older children were faster, more accurate, and lifted their pencil less often than younger children, indicating that their visuomotor abilities are more developed. Even after excluding children who scored ±2 standard deviations of the group mean for total completion time and number of errors, the results remained similar. In the NEPSY-II-NL manual, the amount of errors made during the Visuomotor Precision task and the total time are separate scores; no combined score exists. However, we suggest that the speed/accuracy trade-off requires a joint interpretation. In Figure 4, we present a scatterplot showing both the number of errors made and the total time needed. This figure was made in a smaller sample ($n = 746$) in which outliers (±2 standard deviations from the group mean) on the total completion time and number of errors were excluded. As expected, the figure shows that, even after excluding the extremes, children who are faster tend to make more errors, while children who are slower generally make fewer errors. It also clearly shows that the speed/performance trade-off improves (faster and fewer errors) with increasing age.

With respect to intelligence, we found that performance on most tasks showed a small-to-moderate association with nonverbal IQ, indicating that children with a higher IQ performed significantly better. The fact that the IQ measure was obtained on average 1.7 years earlier could be regarded as a limitation. However, the found relationship between neuropsychological performance and earlier-measured IQ in a way also reflects a level of stability in cognitive functioning. Tasks for which performance did not show a significant association with intelligence were the Auditory Attention, Response Set, and Statue tasks, the Memory for Faces task, and the number of pencil lifts on the Visuomotor Precision task. The strongest associations with intelligence were found on the tasks of the visuospatial-processing domain. This finding might partly be explained by the nonverbal nature of both the visuospatial tasks and the IQ test that was used, although some other NEPSY-II-NL tasks that are also expressively nonverbal (such as the Auditory Attention, Response Set, Statue, Memory for Faces, and Visuomotor Precision tasks) show clearly weaker associations with IQ. As hypothesized, we found performance in the domain of attention and executive functioning to be the least strongly correlated with intelligence.

Although most tasks show an association with intelligence, we do not necessarily conclude that one should always control for intelligence when assessing neuropsychological functioning. As Dennis et al. (2009) pointed out, controlling for IQ in cognitive studies of neurodevelopmental disorders (such as attention-deficit hyperactivity disorder) might even remove some of the true variance and thereby hinder a proper interpretation of findings (Dennis et al., 2009). However, in some cases, controlling for IQ might be advisable—for example, when one would want to study

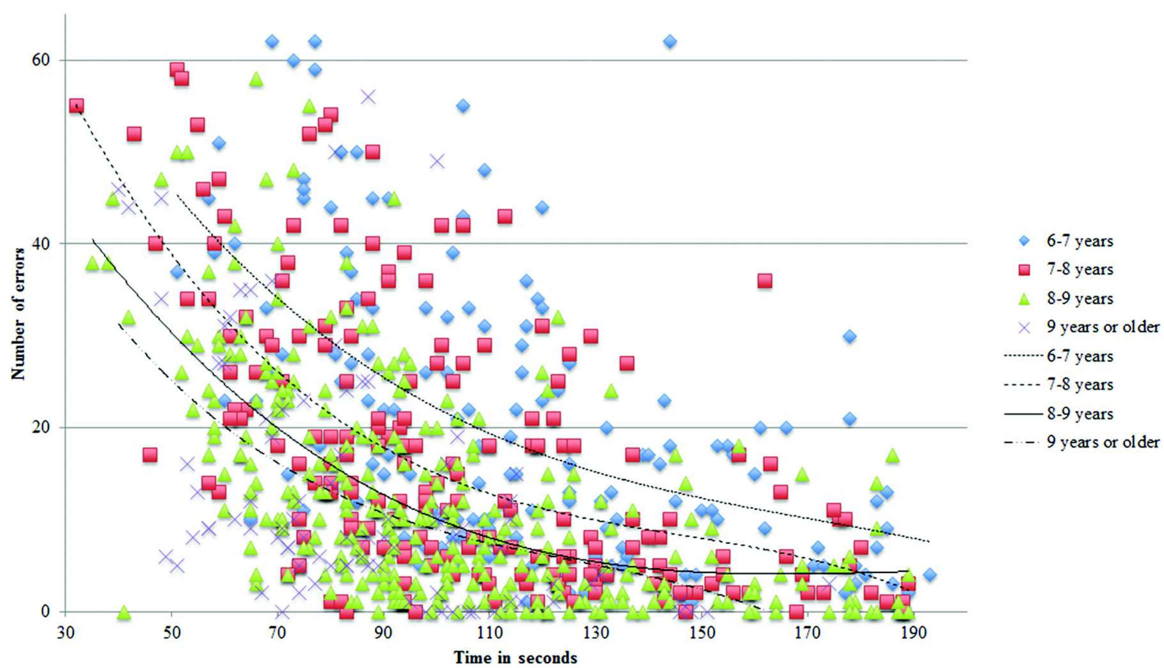

Figure 4. Scatterplot of number of errors and time for the Visuomotor Precision task. Reduced $n = 746$ (outliers ± 2 standard deviations from the mean were excluded). Fit lines are polynomials.

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specific problems that are not explained by general intelligence.

Strengths of the current study include the large sample size and the narrow age range of the children. Because the first (school)years of the child's life are a period of rapid neurocognitive development (Casey et al., 2005; Giedd et al., 1999; Gogtay et al., 2004), it is very important to examine children's cognitive abilities during this age range. Understanding typical development will also help us to better understand aberrant (cognitive) development in young children. A limitation is the cross-sectional character of our study. Because we have not performed longitudinal assessment, we are not able to evaluate true age-related trajectories. In addition, because of time constraints, we were unfortunately not able to administer the entire NEPSY-II-NL battery of 34 tasks. Also, because our intelligence assessment was nonverbal, it might have influenced the results regarding the association between the different (verbal and nonverbal) neuropsychological functions. Finally, because this study was performed in a large multiethnic, urban, and somewhat higher-educated population within The Netherlands, we should be careful in generalizing the findings to the Dutch general population as a whole or to other countries.

To conclude, in the current study on 853 typically developing children aged 6 to 10 years old, we found clear gender-, age-, and intelligence-related differences on various tasks assessing the neuropsychological domains of attention, executive functioning, language, memory, sensorimotor functioning, and visuospatial processing. On nearly all tasks, older children performed better. In addition to age, performance on most NEPSY-II-NL tasks was also related to intelligence, although not all neuropsychological domains showed an equally strong association with intelligence. With respect to gender differences, we found that on most tasks, girls outperformed boys, with the exception of two tasks that required visuospatial abilities, on which boys performed better than girls. Because gender differences in performance on the NEPSY, NEPSY-II, and NEPSY-II-NL have not been previously described and are not being taken into account when calculating norm or percentile scores, this study argues for further investigation of these gender differences during development and the potential formation of separate norm/percentile score conversion tables for boys and girls.

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Table S1. Unadjusted mean test scores per age category.

Task	6–6.5 years n	6–6.5 years Mean (*SD*)	6.5–7 years n	6.5–7 years Mean (*SD*)	7–7.5 years n	7–7.5 years Mean (*SD*)	7.5–8 years n	7.5–8 years Mean (*SD*)
Attention and executive functioning								
Auditory attention								
Total score	76	25.32 (4.44)	107	27.14 (2.94)	108	27.50 (2.86)	121	26.83 (5.01)
Commission errors	76	4.24 (9.27)	107	1.64 (4.92)	108	1.30 (3.57)	121	2.29 (7.06)
Omission errors	76	4.68 (4.44)	107	2.86 (2.94)	108	2.50 (2.86)	121	3.17 (5.01)
Inhibition errors	76	1.57 (4.86)	107	0.54 (3.05)	108	0.39 (2.41)	121	1.38 (5.49)
Response Set								
Total score	74	25.12 (6.72)	104	27.92 (5.44)	107	28.33 (4.97)	120	29.58 (5.12)
Commission errors	74	5.59 (4.08)	104	4.43 (3.45)	107	4.50 (3.63)	120	3.52 (3.19)
Omission errors	74	10.86 (6.73)	104	8.07 (5.44)	107	7.67 (4.97)	120	6.42 (5.12)
Inhibition errors	74	2.35 (2.28)	104	2.13 (2.59)	107	1.66 (2.06)	120	1.57 (2.28)
Statue[a,b]								
Total score	79	27.80 (3.51)	108	27.39 (3.43)	n/a	n/a	n/a	n/a
Total movements	79	1.09 (2.22)	108	1.34 (2.32)	n/a	n/a	n/a	n/a
Total sounds	79	0.47 (1.20)	108	0.69 (1.48)	n/a	n/a	n/a	n/a
Total eye openings	79	0.87 (1.44)	108	0.82 (1.30)	n/a	n/a	n/a	n/a
Language								
Word Generation								
Total semantic score	65	20.25 (5.75)	94	21.51 (6.71)	99	24.67 (6.49)	120	26.63 (6.91)
Memory and Learning								
Memory for Faces								
Total score	78	9.99 (2.30)	107	9.82 (2.53)	114	10.68 (2.15)	122	10.55 (2.30)
Memory for Faces—delayed								
Total score	74	9.82 (2.62)	106	10.02 (2.58)	112	10.84 (2.42)	121	10.92 (2.51)
Narrative Memory[a]								
Total score free and cued recall	69	16.51 (4.74)	106	17.22 (5.26)	105	17.90 (5.65)	109	20.39 (5.27)
Total score free recall	69	11.36 (5.97)	106	12.40 (6.49)	105	13.41 (6.37)	109	16.06 (6.24)
Total score recognition	69	13.88 (1.49)	107	13.65 (1.37)	106	14.08 (1.31)	111	14.23 (1.61)
Sensorimotor function								
Visuomotor Precision								
Total time	78	117.42 (47.32)	109	116.63 (44.89)	112	115.70 (41.00)	121	103.56 (45.09)
Total errors	78	28.86 (28.31)	109	27.19 (26.97)	112	18.36 (19.48)	121	21.50 (24.21)
Total pencil lifts	78	5.27 (6.06)	109	4.92 (6.56)	112	5.39 (7.20)	121	4.46 (5.98)
Visuospatial processing								
Arrows								
Total score	76	20.29 (7.23)	104	23.06 (6.00)	112	25.16 (6.34)	122	24.90 (6.83)
Geometric Puzzles[a]								
Total score	76	26.08 (3.81)	106	26.62 (3.44)	109	26.80 (2.89)	110	28.14 (3.22)
Route Finding[a]								
Total score	68	4.51 (2.86)	99	6.16 (2.93)	103	7.27 (2.46)	107	7.38 (2.60)

Task	8–8.5 years n	8–8.5 years Mean (SD)	8.5–9 years n	8.5–9 years Mean (SD)	9 + years n	9 + years Mean (SD)
Attention and executive functioning						
Auditory Attention						
Total score	201	28.34 (2.16)	125	28.68 (1.71)	96	28.90 (1.66)
Commission errors	201	1.11 (4.39)	125	0.48 (2.20)	96	1.33 (5.62)
Omission errors	201	1.66 (2.16)	125	1.31 (1.67)	96	1.10 (1.66)
Inhibition errors	201	0.50 (3.13)	125	0.18 (1.79)	96	0.86 (4.36)
Response Set						
Total score	202	30.33 (4.18)	125	31.17 (3.45)	97	31.82 (3.50)
Commission errors	202	2.98 (2.36)	125	2.31 (2.09)	97	2.31 (2.00)
Omission errors	202	5.67 (4.18)	125	4.81 (3.44)	97	4.18 (3.50)
Inhibition errors	202	0.90 (1.16)	125	0.83 (1.27)	97	0.88 (1.28)
Statue[a,b]						
Total score	n/a	n/a	n/a	n/a	n/a	n/a
Total movements	n/a	n/a	n/a	n/a	n/a	n/a
Total sounds	n/a	n/a	n/a	n/a	n/a	n/a
Total eye openings	n/a	n/a	n/a	n/a	n/a	n/a
Language						
Word Generation						
Total semantic score	203	28.51 (7.04)	125	30.09 (6.89)	97	32.22 (7.19)
Memory and learning						
Memory for Faces						
Total score	202	10.97 (2.02)	125	11.14 (2.12)	97	11.42 (2.15)
Memory for Faces— delayed						
Total score	203	11.18 (2.33)	125	11.44 (2.41)	97	11.81 (2.33)

(*Continued*)

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Table S1. Continued.

	8–8.5 years		8.5–9 years		9 + years	
Task	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Narrative Memory[a]						
Total score free and cued recall	102	20.45 (5.14)	101	22.98 (4.87)	60	21.87 (6.73)
Total score free recall	102	16.24 (6.26)	101	19.37 (5.90)	60	18.57 (7.40)
Total score recognition	104	14.40 (1.27)	104	14.42 (1.28)	61	14.44 (1.26)
Sensorimotor function						
Visuomotor Precision						
Total time	197	106.53 (41.14)	124	102.83 (41.17)	94	91.66 (38.62)
Total errors	197	14.38 (17.22)	124	14.15 (19.44)	94	13.97 (16.23)
Total pencil lifts	197	4.35 (5.58)	124	3.91 (5.84)	94	3.93 (7.11)
Visuospatial processing						
Arrows						
Total score	203	27.08 (4.44)	126	28.24 (3.95)	97	28.87 (3.86)
Geometric Puzzles[a]						
Total score	131	28.82 (3.50)	109	29.67 (3.37)	60	29.40 (3.20)
Route Finding[a]						
Total score	104	7.87 (2.28)	104	8.38 (2.09)	61	8.56 (1.83)

Note. Unadjusted mean scores and standard deviations are provided.
[a]Not assessed in the shortened NEPSY-II-NL battery that was administered in a subgroup of the participants.
[b]Analyses performed only in 6-year-old children. n/a = not applicable.

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