Exploration of the Internal Structure of the NEPSY-II

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Tutkielma tarkastelee NEPSY-II:n, lasten kognitiivisen testin, sisäistä rakennetta eksploratiivisen faktorianalyysin (EFA) keinoin. Analyysit tehtiin käyttäen NEPSY-II:n suomalaista standardointiaineistoa. NEPSY-II:n rakenne jakautuu käsikirjan perusteella kuuteen kognitiiviseen osa-alueeseen: Tarkkaavuus ja toiminnanohjaus, Kielelliset toiminnot, Muisti ja oppiminen, Sensorimotoriset toiminnot, Sosiaalinen havaitseminen ja Visuospatiaaliset toiminnot. Tutkielman tavoitteena oli: 1) Löytää sopivat faktorirakenteet 3–4-vuotiaille, 5–6-vuotiaille ja 7–15-vuotiaille lapsille; ja 2) Verrata näitä faktorirakenteita NEPSY-II:n kuuteen kognitiiviseen osa-alueeseen. Neljän faktorin rakenne sopi parhaiten joka ikäryhmälle. Näissä faktorirakenteissa oli kolme samankaltaista faktoria: Kielellinen osaaminen, Visuospatiaaliset- ja motoriset taidot ja Prosessointinopeus. Näille kolmelle faktorille latautuvien osatestien kokoonpano kuitenkin vaihteli ikäryhmästä toiseen. Neljän faktorin rakenteet erosivat huomattavasti NEPSY-II:n kuudesta kognitiivisesta osa-alueesta. Yhtäläisyyksien lisäksi faktorirakenteiden välillä oli myös selkeitä eroja osatestien välisissä suhteissa. Tämän tutkielman tuottamaa psykometrista tietoa osatestien välisistä suhteista voidaan hyödyntää myös kliinisessä arvioinnissa. Nyt esitetty tutkimustieto saattaa selkeyttää arviointitilanteessa eri osatestien kohdalla esiin tulevien ongelmien mahdollisia yhteyksiä toisiinsa. Siten se tuo lisänäkökulman kliiniseen arviointiin käytettävissä olevan neuropsykologisen tutkimustiedon lisäksi.

Avainsanat – Nyckelord - Keywords
Arviointi, kehitys, kognitiivinen, neuropsykologinen, neurokognitiivinen, NEPSY-II, rakennevaliditeetti, eksploratiivinen faktorianalyysi, EFA

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Tiivistelmä - Referat – Abstract

The internal structure of the NEPSY-II, a developmental cognitive test, was examined by explorative factor analyses (EFAs). The EFAs were conducted employing the NEPSY-II Finnish standardization sample. The structure of the NEPSY-II, as presented in the manual, is divided into six cognitive domains: Attention and Executive Functioning, Language, Memory and Learning, Sensorimotor Functions, Social Perception and Visuospatial Processing. The objectives of the current study were: 1) To explore what are the best fitting factor structures for 3- to 4-year-old, 5- to 6-year-old, and 7- to 15-year-old children; and 2) To compare the resulting factor structures to the NEPSY-II six cognitive domains. Four-factor structures were found best fitting for all the age groups. These structures shared three roughly similar factors: Language, Visuospatial/Motor Functions, and Processing Speed, although the exact set of subtests loading on each factor differed from one group to another. The four-factor structures considerably differed from the NEPSY-II six cognitive domains. Further, although there were similarities between the factor structures, there were also notable differences in how the subtests related together. The thesis produces scientific knowledge on the relations between the subtests that may also be employed in clinical assessment. The presented psychometrical knowledge might clarify how the problems that present themselves in distinct subtest in an assessment setting are related. Thus, it provides an additional perspective to clinical assessment alongside the prevailing neuropsychological knowledge.

Avainsanat – Nyckelord - Keywords

Assessment, Development, Cognitive, Neuropsychological, Neurocognitive, NEPSY-II, Construct validity, Explorative factor analysis, EFA

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Esipuhe

Haluan ennen kaikkea kiittää Hogrefe Psykologinen Kustannus Oy:tä NEPSY-II:n suomalaisen standardointiaineiston antamisesta käyttööni sekä erityisesti Marja-Leena Haavistoa oman NEPSY-II:n käsikirjansa lainaamisesta tutkielman kirjoittamista varten. Suuret kiitokset myös ohjaajilleni Jari Lipsaselle ja erityisesti Marja Laasoselle erinomaisesta ohjauksesta.

Table of Contents

List of Tables

1. Introduction

Children's cognitive assessment focuses on evaluation of developmental changes, impairments, and strengths within cognitive functions. These functions include, among others, language, visuospatial perception and sensorimotor skills, short- and long-term memory, working memory, processing speed, and attention and executive functioning. The development of cognitive functions is related to the framework of prevailing knowledge of the development of neurological structures and processes. Cognitive assessment of children is most often made in a clinical setting with a specific referral question, and the results contribute to diagnostic and treatment recommendations. There is an underlying assumption that assessment and related diagnosis lead to better interventions and measures of support for children (Riccio, Hynd & Cohen, 1993). However, there has also been criticism of the validity of cognitive assessment tools, value of information gained from assessment, and relevancy of information in the creation of intervention plans (Riccio et al., 1993) as well as of whether assessment results adequately relate to real-life problems and further the understanding of them (Anderson, 2002).

The focus of the current study is on the internal structure and the construct validity of a cognitive assessment tool, the NEPSY-II (Korkman, Kirk & Kemp, 2008a; 2008b). The NEPSY-II is developed to assess 3- to 16-year-old children, and although it is generally employed together with other cognitive tests, its results contribute to diagnostic and treatment recommendations. The following introductive sections review the NEPSY-II development, structure, and validity. The sections thereafter describe the development of cognitive functions and related brain structures. The remaining sections review the findings from the previous studies on the NEPSY, and define the research problems of the current study.

1.1. NEPSY Development

Development of the initial version of the NEPSY (Korkman et al., 2008b) began in the 1970s. The development arose from a perceived need to create a test for the cognitive assessment of children, at a time when there were mainly tests for the assessment of adults. The test development was based on an assessment method designed for adults by Alexander Luria. According to Luria's background theory (Korkman et al., 2008b), cognitive functions are actually complex systems made of several basic components. For example, phonological awareness is one of the components that make up the language system. Assessment of a cognitive disorder requires separate analysis of all the components that make up the disturbed system. Thus, a clinical assessment tool has to be comprehensive enough to provide subtests that cover all the basic components. Accordingly, the NEPSY was developed to facilitate the evaluation of the components that lay underneath developmental and learning problems in all the central cognitive systems (Korkman et al., 2008b), referred in the NEPSY as cognitive domains. In order to keep faithful to Luria's theory, individual subtests were designed to assess the several basic components of verbal, perceptual, motor, attentional, and executive skills (Korkman, 1988).

The modification of an adult assessment method for children has received criticism in that the adult cognitive domains, and their assessment and interpretation methods, may not be suitable for the evaluation of children (Jarrat, 2005). On a more general level, the adult cognitive domains may be perceived as a result of developmental processes, and, as such, might essentially differ from still developing cognitive functions (Karmiloff-Smith, 1998). From this perspective, there may be some domain-relevant mechanisms already in place in childhood, which are more inclined than others to process certain types of input (Karmiloff-Smith, 1998). As these domain-relevant mechanisms repetitively process certain types of input, they might provide a basis for domain-specific mechanisms of fully developed brain structures to emerge (Karmiloff-Smith, 1998).

1.2. NEPSY-II Structure

The NEPSY-II (Korkman et al., 2008b) with standardized norms for 3- to 16-year-old children appeared in 2007 in the United States and in 2008 in Finland. It consists of 29 subtests that comprise a series of items in an order from simple to increasingly complex. The subtests are divided into six cognitive domains: Attention and Executive Functioning, Language, Memory and Learning, Sensorimotor Functions, Social Perception and Visuospatial Processing (see Table 1).

Table 1
NEPSY-II Domain and Subtest Structure

Domain and Subtest	Age	Subtest Description
Attention and Executive Functioning		
Animal Sorting	7-15	This time-limited subtest is designed to assess the ability to formulate concepts, to sort concepts into categories, and to flexibly shift from one category to another.
Auditory Attention	5-15	The first part of the subtest is designed to assess selective auditory attention and the ability to sustain it. The second part is designed to assess the ability to switch attention to, and to sustain it in a new complex task, which requires inhibition of old stimuli.
Clocks	7-15	The subtest is designed to assess visuospatial planning, organization, and understanding of the concept of time.
Design Fluency	5-15	This time-limited subtest is designed to assess non-verbal fluency. A child is asked to connect five dots in as many different patterns as possible.
Inhibition	5-15	This timed subtest is designed to assess the ability to switch response style and to inhibit automatized responses.
Statue	3-6	The subtest is designed to assess motor control and inhibition.
Visual Attention	3-15	This time-limited subtest is designed to assess the ability to sustain selective visual attention.
Language		
Body Part Naming	3-4	The subtest is designed to assess naming and recognition of body parts.
Comprehension of Instructions	3-15	This subtest is designed to assess the ability to perceive, process, and follow verbal instructions with an increasingly more difficult structure.
Phonological Processing	3-15	The subtest is designed to assess phonological awareness. The first part of the subtest demands recognition of a word heard in syllables or in part. The second part requires phonological segmentation. In the third part, a child is asked to form a new word by removing a sound or by replacing it with another one.
Speeded Naming	3-15	The subtest is designed to assess rapid automatized naming of colours, patterns, numbers, and letters.
Word Generation	3-15	This time-limited subtest is designed to assess word production under certain semantic and phonemic categories.
Memory and Learning		
Memory for Designs	3-15	The first part of the subtest is designed to assess learning of new visuospatial material. The second, delayed part is designed to assess long-term visuospatial memory.
Memory for Faces	5-15	The first part of this subtest is designed to assess learning, differentiation, and recognition of facial characteristics. The second, delayed part is designed to assess long-term facial memory.
Memory for Names	5-15	The first part of the subtest is designed to assess learning of names related to facial pictures over three trials. The second, delayed part is designed to assess long-term name memory.
Narrative Memory	3-15	This subtest is designed to assess recall of a narrative first freely, then with the help of cues, and finally by recognition.
Sentence Repetition	3-6	The subtest is designed to assess repetition of sentences of increasing length and difficulty.
Word List Interference	7-15	This subtest is designed to assess verbal short-term and working memory. A child is asked to repeat increasingly long series of words, and to recall them after an interruption.
Sensorimotor Functions		
Finger Tapping	5-15	The subtest is designed to assess finger dexterity, motor speed, and rapid motor programming.
Imitating Hand Positions	3-15	This subtest is designed to assess imitation of hand and finger positions.
Visuomotor Precision	3-15	This timed subtest is designed to assess fine motor speed and precision, and visuomotor coordination.
Finger Differentiation	5-15	This subtest is designed to assess the finger differentiation on the basis of tactile information.
Social Perception		
Affect Recognition	3-15	The subtest is designed to assess recognition of emotions from facial photos of children.
Theory of Mind	3-15	This subtest is designed to assess the ability to understand another person's perspective, and to recognize and understand emotions related to different social situations.

(Continued)

Table 1 (Continued)

Domain and Subtest	Age	Subtest Description
Visuospatial Processing		
Arrows	5-15	The subtest is designed to assess perception of line directions.
Block Construction	3-15	This timed subtest is designed to assess visuospatial and constructive abilities. A child is asked to build a three-dimensional constructions, either on the basis of a model or a picture.
Design Copying	3-15	The subtest is designed to assess visuospatial and motor abilities to perceive and draw two-dimensional geometrical patterns.
Geometric Puzzles	3-15	This subtest is designed to assess differentiation of geometric patterns by comparing their general form and details, and by mentally rotating them.
Picture Puzzles	7-15	The subtest is designed to assess the visual abilities of perception, differentiation, spatial location and search. It is also designed to assess the ability to deconstruct a picture into parts, and to perceive part-whole relationships.

Note. Table adapted from Korkman et al., 2008b, p. 24-26. Translated with the help of a similar table from Kemp & Korkman, 2010, p. 16-21.

It is noteworthy that the NEPSY-II six-domain structure considerably differs from that of some other developmental cognitive tests, such as Wechsler Preschool and Primary Scale of Intelligence IV (WPPSI-IV) for 2,5- to 7,5-year-old children, and Wechsler Intelligence Scale for Children V (WISC-V) for 6- to 16-year-old children. These Wechsler's tests have a five-domain structure for 4- to 16-year-olds that comprises Verbal Comprehension, Visual Spatial abilities, Working Memory, Fluid Reasoning, and Processing Speed, and a three-domain structure for under 4-year-olds that comprises the first three domains of the former (Canivez & Watkins, in press; Raiford & Coalson, 2014). WPPSI-IV and WISC-V have been developped with the help of factor analysis, and its results provide a basis for their domain structure of cognitive functioning (Canivez & Watkins, in press; Raiford & Coalson, 2014). Factor analysis was decided not to be employed in the NEPSY-II development (see Korkman, 1988), a decision that has later been challenged by some authors (Jarrat, 2005; Mosconi, Nelson & Hooper, 2008; Stinnett, Oehler-Stinnett, Fuqua & Palmer, 2002).

A set of NEPSY-II subtests administered to a child differs depending on the child's age and the purpose of evaluation. There is a manual-based, generally recommended set of subtests, the core assessment, which includes the clinically most sensitive[1] tests for discovering any cognitive impairment (Korkman et al., 2008b). It includes subtests from all the domains except for Social Perception. The core assessment is recommended for all

[1] It may be noted here that sensitive and specific are employed in the NEPSY-II manual in a general meaning of the words, and should not be confused with the respective statistical terms. The statistical definition (see e.g. Glaros & Kline, 1988) of sensitivity is the capacity of a test to correctly identify the persons who fill the diagnostic criteria of a disorder from those who do not. Respectively, specificity is defined as the capacity of a test to correctly identify the persons who do not fill the criteria of a disorder from those who do.

children when their difficulties are either not clearly defined, or when there are multiple difficulties. There are also manual-based recommended sets of subtests for children suspected of distinct cognitive impairments that have been found to best distinguish these children from typically developing controls (Korkman et al., 2008b). There are such recommendations for children suspected of problems of attention and concentration; reading and writing difficulties; mathematical learning difficulties; specific language impairment; perception or motor impairment; problems of social interaction; behavioural and emotional problems; and lack of school readiness. The assessment of a 3- to 4-year-old child with the NEPSY-II takes approximately an hour, and the assessment of a 5- to 15-year-old child between one and two hours, depending on the selected subtests (Korkman et al., 2008b).

The NEPSY-II subtests are, according to the manual, divided into the domains on the basis of their theoretical instead of statistical qualities (Korkman et al., 2008b). Thus, the domain scores (averages over the domain subtests) are not calculated, as they are in some other cognitive tests, such as, Wechsler's. In the NEPSY-II, cognitive processes measured by a subtest (e.g., Word Generation) are not assumed to restrict to the domain where the subtest is located (Language), but extend to other domains (e.g., Attention and Executive Functioning) (Korkman et al., 2008b). The subtests under each domain are presumed to differ from one another regarding to what kind of stimuli are employed and how they are presented, as well as what kind of answers are required and how they are scored. Therefore, the subtests under the same domain do not necessarily correlate with each other, whereas subtest under different domains may correlate because of their methodological similarities (Korkman et al., 2008b). Furthermore, subtests designed to evaluate complex skills, which strain performance with various concurrent demands, are expected to be more sensitive than are subtests developed to assess skills' basic components. Thus, a subtest of verbal reasoning or memory may be more sensitive to uncover subtle verbal difficulties than, for instance, a subtest of phonological awareness (Korkman et al., 2008b).

The individual subtests are assumed to be, as such, clinically sensitive and valuable in evaluating primary impairments behind the cognitive problems both within and between domains (Korkman et al., 2008b). It is, however, emphasized that poor results in a single subtest do not suffice for drawing any clinical conclusions. As a rule of thumb presented in the manual, there should be problems in at least two subtests within a domain, and these problems have to be logically related within the framework of neuropsychological research (Korkman et al., 2008b). Even though every subtest in the NEPSY-II is designed to measure some specific component of cognitive functions, performance in any subtest always depends on various factors, and poor performance has as many possible explanations (Korkman et al., 2008b).

To summarize some relevant points in regard to the current study, subtests within a domain may not correlate together, whereas subtests from different domains might do. In the explorative factor analysis (EFA), such correlations between the subtests may reflect to the factor structures in a way that the subtests might not load domain-specifically. Instead, some subtests may load together with those that require similar cognitive skills, such as, serial processing or processing speed. Other subtests, in contrast, might load together with those that are presented to a child in a similar way, such as, with the help of visual support.

1.3. NEPSY-II Validity

The focus of the current study is on the internal structure and the construct validity of the NEPSY-II. Construct validity, a term increasingly employed to refer to the overall validity, implies the degree to which an instrument measures what it is intended to (Cook & Beckman, 2006). In other words, the term indicates the degree to which a score of an instrument (e.g., a cognitive test) may be interpreted to represent the assumedly underlying construct (e.g., the overall cognitive functioning) (Cook & Beckman, 2006; Downing, 2003). Constructs represent latent variables, which themselves are not directly observable (Cronbach & Meehl, 1955), but are assumed to be reachable by assessing other, directly measurable, variables (e.g., accuracy of answers or speed of processing) (Cronbach & Meehl, 1955). EFA, the method employed in the current study, is one of the means applied to identify the latent variables that assumedly account for the correlations between the observed variables (Norris & Lecavalier, 2010).

Construct validity may be supported by evidence from five sources (as listed by, e.g., Cook & Beckman, 2006; Downing, 2003; the list is originally based on AERA, APA, & NCME, 1999): 1) Content: Do the test items cover all the aspects of a construct, and only the aspects of the construct? 2) Response process: What is the relation between the test items and the assumedly respective aspects of cognitive and other mental processes? 3) Internal structure: Are the individual items reliable, and does the test have a sound internal structure? 4) Relations to other variables: Do the test scores correlate with those of other testing methods designed to assess the same construct? 5) Consequences: Do the test scores provide a solid basis for making clinical decisions and predicting outcomes?

Considering the above five sources, construct validity is covered in the NEPSY-II manual primarily in terms of two of them: 3) Internal structure, from the perspective of subtest reliability and subtest intercorrelations; and 4) Relations to other developmental cognitive tests. Subtest reliability is covered either in terms of internal consistency or temporal stability, depending on the features of the subtest[2]. The correlations of the subtests with those of other developmental cognitive tests, such as, WISC-IV, are reported to produce coefficients of moderate to fairly strong value[3].

According to the NEPSY-II manual, significant subtest intercorrelations provide information of the strength of relations between the subtests that are designed to measure similar constructs. Thus, the subtest intercorrelation matrices are assumed to provide information of the internal structure and contribute to the construct validity (Korkman et al., 2008b). Nevertheless, it should be kept in mind that because of methodological properties of the subtests, those under the same domain do not necessarily correlate with each other, whereas subtests from different domains may do (Korkman et al., 2008b).

[2] Internal consistency for the whole NEPSY-II standardization sample was estimated by calculating Cronbach's Alphas for the set of items included in each subtest (Korkman et al., 2008b). The Alpha values ranged from very high for Phonological Processing (.96) to low for Clocks (.58). Internal consistency for age groups with one-year intervals was estimated by calculating either Cronbach's Alpha, split-half-reliability, or test-retest reliability (within the US standardization sample) for the set of items included in each subtest (Korkman et al., 2008b). The test-retest reliability was calculated for subtests that do not consist of sections, and thus did not allow for counting the two other coefficients. The Cronbach's Alpha, split-half, and test-retest reliability values ranged from very high, for 7- to 8- and 11-year-old Finger Tapping Serial Task (.99), to non-existent, for 5-year-old Memory for Faces (.00) and 9-year-old Theory of Mind Contextual Task (.00). In regard to the interpretation of the reliability estimates, it may be noted that although Alpha values of over .70 are often preferred, higher Alpha values are not necessarily always the better, because values of over .90 indicate more likely redundancy than homogeneity of items (Streiner, 2003).

[3] The highest subtest intercorrelations between NEPSY-II and WISC-IV (Korkman et al., 2008b) are between NEPSY-II Word List Interference and WISC-IV Digit Span (.63) and NEPSY-II Comprehension of Instructions and WISC-IV Vocabulary (.62). There are also high intercorrelations between WISC-IV Block Design and three NEPSY-II subtests: Block Construction (.59), Picture Puzzles (.56), and Design Copying (.52). The highest intercorrelations between NEPSY-II subtests and WISC-IV indexes are between NEPSY-II Word List Interference and WISC-IV Working Memory Index (.63), and NEPSY-II Picture Puzzles and WISC-IV Perceptual Reasoning Index (.62).

Unfortunately, the Finnish manual does not provide subtest intercorrelation matrices for the Finnish standardization sample of the typically developed children. These values are presented only for the children with neurocognitive difficulties within the US standardization sample. Therefore, the subtest correlation matrices for the Finnish standardization sample are provided in the current study (see Appendices 2–6). The correlation matrices are, however, not analysed in this study as such. Instead, they are explored by the means EFAs, and the resulting factor loading matrices are analysed. The underlying constructs behind the observed relations revealed by the EFAs are considered in the discussion. This way, the current study strives to contribute to the research on the construct validity of the NEPSY-II.

1.4. Cognitive and Brain Development

The NEPSY-II has standardized norms for 3- to 16-year-old children and thus can be employed to follow a child's cognitive development over a wide age span (Korkman et al., 2008b). The pace of cognitive development has been generally linked to the rate of maturation of frontal and prefrontal lobes as well as other cortical areas (Fuster, 2002; Romine & Reynolds, 2005). Thus, developmental cognitive test performance should also be regarded from the perspective of brain maturation (Jarrat, 2005). Therefore, a brief review of research on cognitive and brain development is relevant, before proceeding to the previous studies on the internal structure and the construct validity of the NEPSY-II, in order to give some perspective to the latter.

Cognitive development, as assessed by the NEPSY-II, is rapid from 5 to 9 years (Korkman, Lahti-Nuuttila, Laasonen, Kemp & Holdnack, 2013). 9 years of age is a turning point, after which the rate of development decelerates, and continues at a significantly slower pace. Children develop mastery in most NEPSY-II subtests at the age of 12 to 13 years (mastery is defined as the age when the subtest score group mean does not significantly differ from the 16-year-old group mean) (Korkman et al., 2013). Mastery is reached even earlier, at the age of 11, in subtests assessing social perception. Children reach peak performance for most NEPSY-II subtests later than mastery, at the age of 14 to 16 years (peak performance is defined as the age when the subtest score group mean reaches its maximum level). Peak performance remains to be reached beyond the age of 16 in some aspects of executive functioning, verbal memory as well as visuospatial perception and construction (Korkman et al., 2013).

The deceleration of the rate of cognitive development after the age of 9 may parallel the peaking of brain volume between 10 and 15 years of age (in average at 10,5 years in females and at 14,5 years in males) (Korkman et al., 2013; Lenroot et al., 2007). The peaking of brain volume is generally assumed to parallel a shift from acquisition of new cognitive functions to consolidation and increase of efficiency and integrity of the already acquired skills (see e.g. Korkman et al., 2013). Functions that require a high level of integration between different brain areas, such as, language continue to develop into adulthood (Fuster, 2002).

The peaking of brain volume is closely related to the volume of cortical grey matter, which grows nonlinearly, a preadolescent volume increase followed by a postadolescent decrease (Giedd et al., 1999). The growth of cortical grey matter is regionally specific. The frontal and parietal lobe growth peak around the age of 12 and the temporal lobe around the age of 16 (Giedd et al., 1999). The prefrontal areas peak around the age of 18 (Kanemura, Aihara, Aoki, Araki & Nakazawa, 2003), whereas the occipital lobe continues to grow through the age of 20 (Giedd et al., 1999). The region-specific rate of growth may correspond to the late achievement of peak performance in some of aspects verbal memory and visuospatial perception (Korkman et al., 2013). In contrast to the grey matter, the cortical white matter volume grows linearly, and its growth is mostly attributable to the myelination of axons (Fuster, 2002). Myelin accelerates the rate of axonal conduction and, thus, is presumed to improve the processing and coordination of cortical networks (Fuster, 2002).

The frontal lobes, which reach their peak volume around the age of 12 (Giedd et al., 1999), may be more involved than other brain areas in complex tasks in that they coordinate the activity among distinct anatomical and functional areas (Alvarez & Emory, 2006). The frontal lobes have numerous connections to cortical, subcortical, and brain stem sites (Alvarez & Emory, 2006) and to the cerebellum (Diamond, 2000). These connections provide indispensable input for the higher-level integrative and coordinative functions, which are based on lower-level processes of perception, cognition, and behaviour (Alvarez & Emory, 2006).

To summarize, brain structures mature through childhood and adolescence and different brain areas mature at a different rate. Although brain volume peaks between 10 and 15 years of age, maturing continues in the frontal and prefrontal lobes, and in other brain regions, especially in the parietal, temporal, and occipital lobes. This is relevant in regard to the developmental cognitive assessment across a wide age span. The assessment with NEPSY-II, for example, is based on an implicit assumption that the six cognitive domains remain relatively stable across development and stay similar between the age groups. The following section reviews research findings related to the internal structure and the construct validity of the NEPSY, and also touches upon the question of whether the cognitive functioning of children can be adequately described by a uniform structure across a wide age span.

1.5. Previous Studies on the Structure of the NEPSY

The previous studies on the internal structure and construct validity were made on the NEPSY, the preceding five-domain version of the NEPSY-II, which excludes the Social Perception domain. A five-factor structure, suggested by the five cognitive domains, did not receive support. Instead, the factor structure of the NEPSY was proposed to be best described by a one-factor Language model (Stinnett et al., 2002; Jarrat, 2005) and by a four-factor model. The four-factor model was originally based on the five domains, out of which the Attention and Executive Functioning domain was dropped out because of poor fit (Mosconi et al., 2008).

The one-factor Language model was first put forward by Stinnett et al. (2002) based on the findings from EFA with the NEPSY US standardization sample of 5- to 12-year-old children. The EFA resulted in one robust factor, which reflected aspects of linguistic-verbal ability. Stinnett et al. (2002) concluded that because the one Language factor best explained NEPSY structure, a child's performance on the domains of Attention and Executive Functions, Sensorimotor Functions, Visuospatial Processing, and Memory and Learning should not be interpreted as if the domains measured distinct groups of cognitive functions. In contrast, interpretation of the test results within the five-domain structure "could potentially lead to very faulty decision making about a child's neuropsychological status" (Stinnett et al., 2002, p. 78). In terms of the NEPSY subtest specificity, Stinnett et al. (2002) found that only two subtests, Phonological Processing and Memory for Names, had sufficient unique variance combined with low error variance to be interpreted independently from the one Language factor. Nine subtests, in turn, were too unreliable to be interpreted in isolation for clinical or practical purposes. These were Comprehension of

Instructions, Speeded Naming, Design Copying, Narrative Memory, Arrows, Visual Attention, Visuomotor Precision, Finger Tapping, and Memory for Faces. On the basis of their findings, Stinnet et al. claimed it unlikely that the NEPSY could "detect *subtle* deficiencies in neuropsychological functioning of children" (2002, p.79, emphasis in original).

It may be noted here that a one-factor model is highly parsimonious, but the high degree of parsimony comes with a low level of variance explained. The one Language factor of Stinnett et al. (2002) accounted for only 25% of variance and, thus, left the majority of variation in test performance unexplained. The one-factor model also carries a risk of underextraction of factors, which raises the probability of error in the estimated factor loadings (Wood, Tataryn & Gorsuch, 1996). Therefore, underextraction is advised to be avoided, even at the cost of overextraction (Wood et al., 1996).

The one-factor Language model did, however, receive further support from the findings of Jarrat (2005), who examined the fit of four theoretical models on the NEPSY by confirmatory factory analysis (CFA) with a sample of 48 children aged 5 to 8 years. The examined models were the one-factor Language model based on Stinnet et al. (2002); a three-factor developmental model based on a division between language, visuospatial, and sensory abilities; a three-factor Lurian model based on a separation of executive functions, attention/memory, and visuospatial/sensory abilities; and a five-factor-model based on the five-domain structure of the NEPSY. The one-factor Language model with correlated error scores resulted in the best fitting model to the data. Jarratt (2005) concluded the finding to emphasize the importance of language development over that of other cognitive functions in young children.

The sample size of 48 children of Jarratt was small compared to the standardization samples, a limitation also recognized by the author (2005). Although there is no rule of thumb for CFA sample size, Monte Carlo methods, not employed in the above study, could have been applied to determine the sample size and to estimate power (Myers, Ahn & Jin, 2011).

In addition to the one-factor Language model, the internal structure of the NEPSY was proposed to be best described by a four-factor model of Language, Memory and Learning, Sensorimotor Functions, and Visuospatial Processing. The four-factor-model was put forward by Mosconi et al. (2008), who examined the fit of three theoretical models on the NEPSY by CFA with the US standardization sample of 5- to 12-year-old children. The sample was examined as a whole and as divided into a younger, 5- to 8-year-old, and an older, 9- to 12-year-old, group. The five-factor manual-based model proved inadequate for the entire sample, and produced negative error variance for the younger and older age groups. The main problem appeared to be related to the lack of integrity of the subtests within the Attention and Executive Functions domain. The whole domain was left out and a four-factor model was examined. This resulted in satisfactory fit statistics for the whole sample and for the younger age group, but not for the older group. A one-factor model, in turn, proved inadequate for the whole sample. Thus, the four-factor model fitted the data best for the whole sample and for the younger age group, whereas none of the examined factor models fitted well for the older age group. These results indicate that the structure of the NEPSY is not age-invariant (Mosconi et al., 2008). On the basis of their findings, Mosconi et al. proposed that four out of five NEPSY domains may be psychometrically defendable and, thus, clinically relevant for 5- to 12-year-old and for the subgroup of 5- to 8-year-old children. In the case of 9- to 12-year-old children, in contrast, the subtests should be interpreted individually, instead of as representative of their domains. This also applies to the subtests of the Attention and Executive Functions domain across all the age groups (Mosconi et al. 2008).

To summarize, the previous findings on the factor structure of the NEPSY suggest that it does not conform to the five cognitive domains (Jarrat, 2005; Mosconi et al., 2008; Stinnett et al., 2002) and that it is not age-invariant (Mosconi et al., 2008). The previous findings on the structure of the NEPSY were, however, based on the five-domain version, which is replaced in clinical use by the six-domain NEPSY-II. Further, the previous studies examined the structure of the NEPSY employing the US standardization sample. The factor structure of the NEPSY-II employing the Finnish standardization sample is explored for the first time in the current study.

1.6. Research Problems

Research on the psychometrical structure of the NEPSY-II may advance understanding of the relations between the cognitive functions that the test is designed to measure. There are many open questions. Which functions correlate positively together? Which fluctuate independently of each other? Although few subtests are expected to correlate negatively, are there any that do? What explanations does the prevailing knowledge on cognitive and neural development provide for the observed correlations? Could psychometrical research provide some new aspects for understanding the relations between difficulties in different cognitive functions?

EFA is a psychometrical method employed to gain additional information from correlation matrices. It is applied to reveal the latent variables that are assumed to account for the observed correlations (Norris & Lecavalier, 2010). In the current study, EFAs are conducted separately for the subtest standard point correlation matrices of 3- to 4-year-old, 5- to 6-year-old, and 7- to 15-year-old children. The analyses are conducted separately, for one thing, because the NEPSY-II has different sets of subtests for each age group. For another thing, the structure of the underlying cognitive functions is assumed to vary from one age group to another considering that the neural structures related to cognitive functions and the functions themselves are still in the process of development (Jarrat, 2005). This is predicted to reflect onto the factor structures as differences between the age groups (Jarrat, 2005; Mosconi et al., 2008; Stinnett et al., 2002). Further, the 7- to 15-year-old group is divided into 7- to 9-year-old and 10- to 15-year-old subgroups, because cognitive development reaches a turning point at the age of 9 (Korkman et al., 2013), and this is presumed to reflect onto the factor structures as differences between these sub groups.

Thus, the EFAs are conducted on groups of 3- to 4-year-old, 5- to 6-year-old, and 7- to 15-year-old children, and on subgroups of 7- to 9-year-old and 10- to 15-year-old children. The resulting factor structures are reviewed to respond to the following research problems:

1) What is the best fitting factor structure for each age group?
2) How does the factor structure of each age group compare with the six cognitive domains of the NEPSY-II?

2. Methods

2.1. Participants

The NEPSY-II Finnish standardization sample was employed in this study (923 children, 500 females and 423 males, Tables 2-3). The sample was gathered from 2006 to 2007 with the help of the population register (Korkman et al., 2008b). The register was searched for children whose age at the time of research was within two months of any of the predetermined age groups, who lived in one of the four towns and two rural municipalities in which the sample was to be gathered, and who were native Finnish speakers. The children who met the criteria were randomly sampled, and altogether 6006 of their caretakers were sent a letter to inform them of the research. All in all 1020 answers were received and finally 923 children were assessed (Korkman et al., 2008b).

Table 2
3- to 15-year-old Groups

Age group	Lower limit	Upper limit	Girls	%	Boys	%	Total
3-4 years	2 years 10 months	4 years 2 months	109	53.2	96	46.8	205
5-6 years	4 years 10 months	6 years 2 months	118	53.9	101	46.1	219
7-15 years	6 years 10 months	15 years 2 months	273	54.7	226	45.3	499
Total			500	54.2	423	45.8	923

Table 3
7- to 15-year-old Subgroups

Age group	Lower limit	Upper limit	Girls	%	Boys	%	Total
7-9 years	6 years 10 months	9 years 2 months	128	50.8	124	49.2	252
10-15 years	9 years 10 months	15 years 2 months	145	58.7	102	41.3	247
Total			273	54.7	226	45.3	499

Examined background variables in the current study, in addition to children's gender and age, were form of day care before primary school and parents' basic and further education. The form of day care was in the majority of cases kindergarten. Parents' education was found to be higher than average: in 25% of cases both parents had a university level degree, and in 54% of cases at least one of the parents had such a degree[4] (see Appendix 1).

[4] In comparison, 29% of the Finnish adult population has a university level degree (Official Statistics of Finland (OSF), 2014).

2.2. Instrumentation

The NEPSY-II (Korkman et al., 2008b) consists of 29 subtests that comprise a series of items in an order from simple to increasingly complex. The subtests are divided into six cognitive domains: Attention and Executive Functioning, Language, Memory and Learning, Sensorimotor Functions, Social Perception and Visuospatial Processing. In the standardization research, the children were administered the full set of subtests available for their age group. In clinical use, a narrower set of subtests is administered, their selection depending on the child's age and the purpose of evaluation. (For more information on the NEPSY-II, see sections 1.1. NEPSY Development; 1.2. NEPSY-II Structure; 1.3., and NEPSY-II Validity.)

2.3. Procedure

In order to prepare the data to conduct the EFAs on the subtest standard point correlation matrices, missing values among the standard points were analysed and replaced. The missing values remained mostly under 10%, except for 3- to 4-year-old Word Generation (18%) and Statue (15%), and 5- to 6-year-old Memory for Names (16%) and Speeded Naming (11%). As the percentage of missing values remained mostly low, and the missing values did not follow any systematic pattern, they were replaced employing the Expectation Maximization (EM) algorithm. With the missing values replaced, subtest standard point intercorrelation matrices were calculated for each age group. All the statistical analyses were made with SPSS Statistics Version 21.

The number of factors chosen in the EFA to the best-fitting factor solution may be determined by various criteria, out of which parallel analysis is a currently recommended procedure (O'Connor, 2000). Parallel analysis involves creating random data sets, which parallel the original data set in terms of the number of cases and variables. The eigenvalues extracted from the random data are compared with those from the original data (O'Connor, 2000). The upper limit for the number of factors is determined by the number of eigenvalues from the original data that are greater than the eigenvalues corresponding to the 95th percentile of the distribution from the random data. (O'Connor 2000.) In the current study, the upper limit for the number of factors given by parallel analysis was five for all the age groups.

The EFAs were conducted on groups of 3- to 4-year-old, 5- to 6-year-old, and 7- to 15-year-old children, and on subgroups of 7- to 9-year-old and 10- to 15-year-old children. On the basis of the parallel analysis, one-, two-, three-, four- and five-factor solutions were tried on each age group. The EFAs were computed with maximum likelihood extraction and oblimin rotation. A cut-off value of .30 was chosen as the lowest acceptable factor loading for including a subtest on a factor. The best fitting factor structure for each age group was chosen on the grounds of statistical criteria (results of parallel analysis, communality estimates and amount of variance explained) and theoretical interpretability. The factors were named on basis of the functions required by the subtests that most strongly loaded on and, thus, defined each factor.

3. Results

Subtest standard point intercorrelation matrices were calculated for each age group (see Appendices 2-6). The highest subtest intercorrelations were in the 7- to 15-year-old group between Comprehension of Instructions and Phonological Processing (.52), and between Comprehension of Instructions and Word List Interference (.52). The majority of correlations were much lower, but nevertheless positive. An exception was 5- to 6-year-old Finger Tapping, which correlated negatively with all the other subtests.

The number of factors to be extracted for each age group was determined based on the earlier specified criteria (see section 2.3. Procedure). Four-factor structures were extracted for the groups of 3- to 4-year-old, 5- to 6-year-old, and 7- to 15-year-old children. The 3- to 4-year-old factors were named 1) Language; 2) Visuospatial/Motor Functions; 3) Motor Inhibition; and 4) Processing Speed and Fine Motor Functions (see Tables 4-5). The factors of 5- to 6-year-old were named 1) Processing Speed and Working Memory; 2) Language; 3) Task Switching and Repetitive Learning; and 4) Visuospatial/Motor Functions (see Tables 6-7). The 7- to 15-year-old factors were, in turn, named 1) Visuospatial/Motor Functions; 2) Facial Processing; 3) Language; and 4) Processing Speed and Fluency (see Tables 8-9). The reliability of the factor loadings was estimated by Cronbach Alpha (see Table 10). These factor solutions are reviewed in the discussion.

Five-factor structures were extracted for the subgroups of 7- to 9-year-old and 10- to 15-year-old children (see Appendices 7-10). However, the factor structures of the 7- to 15-

year-old group and its 7- to 9-year-old and 10- to 15-year-old subgroups were in many aspects similar. Because of the similarities, the subgroup division was not considered to provide enough information value to justify itself, and the 7- to 15-year-old children were decided to be analysed as a single group.

Table 4
3- to 4-year-old Subtest Factor Loadings in a Four-Factor Structure

Subtest	Factor				Communality
	Language	Visuospatial/ Motor Functions	Motor Inhibition	Processing Speed and Fine Motor Functions	
Theory of Mind	**.66**			-.16	.40
Narrative Memory	**.64**		.16	-.12	.48
Sentence Repetition	**.53**			.14	.45
Phonological Processing	**.41**		-.11	.21	.23
Body Part Naming	**.39**			.17	.27
Affect Recognition	**.33**	-.11	.21	.29	.34
Word Generation	.29	.23	.24		.35
Block Construction		**.76**			.60
Geometric Puzzles		**.51**	-.10	.29	.43
Imitating Hand Positions		**.44**	.13		.26
Statue			**.76**	.10	.63
Comprehension of Instructions	.28	.11	-.15	**.53**	.52
Speeded Naming			.21	**.45**	.34
Design Copying		.20		**.40**	.32
Visuomotor Precision				**.35**	.14
Visual Attention				.27	.12
Eigenvalue	4.58	1.45	1.15	1.08	
% of Variance Explained	28.64	9.05	7.19	6.74	
Cumulative %	28.64	37.69	44.88	51.63	

Factor loadings >.30 are in bold

Table 5
3- to 4-year-old Factor Intercorrelations

Factor	Language	Visuospatial/Motor Functions	Motor Inhibition
Language			
Visuospatial/Motor Functions	**.34**		
Motor Inhibition	**.31**	.27	
Processing Speed and Fine Motor Functions	**.43**	**.43**	.22

Correlations >.30 are in bold.

Table 6
5- to 6-year-old Subtest Factor Loadings in a Four-Factor Structure

Subtest	Factor				Communality
	Processing Speed and Working Memory	Language	Task Switching and Repetitive Learning	Visuospatial/Motor Functions	
Comprehension of Instructions	**.79**	.11	-.11		.66
Visual Attention	**.48**				.26
Speeded Naming	**.43**	.22	.17		.37
Arrows	**.40**		.17	.12	.30
Auditory Attention	.29	.23	.18		.30
Geometric Puzzles	.19		.11	.16	.17
Narrative Memory		**.87**	-.16	.18	.77
Memory for Names		**.55**	**.31**	-.12	.43
Sentence Repetition	**.35**	**.39**	-.24	.20	.47
Word Generation	.18	**.37**			.28
Theory of Mind	**.35**	**.35**			.37
Phonological Processing	.22	.28	.13		.25
Design Fluency	.19	.22			.19
Inhibition			**.55**	.14	.43
Memory for Faces		.10	**.39**		.22
Memory for Designs	**.31**		**.34**		.29
Block Construction	.23		.26	.18	.28
Imitating Hand Positions		.15		**.59**	.39
Finger Tapping		-.10		**-.46**	.24
Design Copying	.18		.26	**.42**	.44
Finger Differentiation	.13	-.15		**.41**	.22
Visuomotor Precision			**.32**	**.36**	.31
Affect Recognition			.14	**.36**	.18
Statue	.25			**.32**	.22
Eigenvalue	6.30	1.68	1.33	1.21	
% of Variance Explained	26.26	7.02	5.53	5.04	
Cumulative %	26.26	33.28	38.80	43.85	

Factor loadings >.30 are in bold

Table 7
5- to 6-year-old Factor Intercorrelations

Factor	Processing Speed and Working Memory	Language	Task Switching and Repetitive Learning
Processing Speed and Working Memory			
Language	**.40**		
Task Switching and Repetitive Learning	**.38**	.23	
Visuospatial/Motor Functions	**.54**	.28	**.33**

Correlations >.30 are in bold.

Table 8
7- to 15-year-old Subtest Factor Loadings in a Four-Factor Structure

Subtest	Factor				Communality
	Visuospatial/Motor Functions	Facial Processing	Language	Processing Speed and Fluency	
Picture Puzzles	**.63**	.23	-.13		.53
Arrows	**.57**				.31
Block Construction	**.53**			.27	.41
Geometric Puzzles	**.49**		.16	.11	.38
Imitating Hand Positions	**.49**		.19		.34
Design Copying	**.45**	.13			.34
Inhibition	**.38**		.22	.25	.42
Memory for Designs	**.35**	.29		.10	.31
Clocks	**.32**		**.30**		.32
Finger Differentiation	**.32**		.25	-.18	.21
Visuomotor Precision	**.30**	.11			.13
Affect Recognition	.28	.12	.17		.19
Finger Tapping	-.25				.07
Memory for Names	-.16	**.64**	**.36**		.59
Memory for Faces		**.53**		-.10	.29
Visual Attention	.14	**.46**	-.10	.22	.34
Comprehension of Instructions			**.61**	.16	.53
Word List Interference			**.54**	.18	.45
Phonological Processing	.24	.13	**.51**		.53
Narrative Memory		.15	**.37**	.26	.36
Theory of Mind	.24	.26	**.30**		.41
Word Generation	-.13	.20	.20	**.61**	.52
Design Fluency	.15	-.12		**.55**	.36
Animal Sorting		.16		**.35**	.25
Speeded Naming	.11		.26	**.34**	.29
Auditory Attention	.23		.16	.23	.24
Eigenvalue	7.42	1.48	1.43	1.27	
% of Variance Explained	28.52	5.69	5.50	4.89	
Cumulative %	28.52	34.21	39.72	44.61	

Factor loadings >.30 are in bold

Table 9
7- to 15-year-old Factor Intercorrelations

Factor	Visuospatial/Motor Functions	Facial Processing	Language
Visuospatial/Motor Functions			
Facial Processing	**.35**		
Language	**.49**	.27	
Processing Speed and Fluency	**.40**	.23	**.32**

Correlations >.30 are in bold.

Table 10
Factor Loading Reliability Estimates

Factor	Age		
	3-4	5-6	7-15
1	**.73**	.68	**.82**
2	.65	**.74**	.61
3	*	.55	**.79**
4	.60	.59	.64

* The factor has only one subtest
Cronbach Alpha values >.70 are in bold.

4. Discussion

In the current study, EFAs were conducted on groups of 3- to 4-year-old, 5- to 6-year-old, and 7- to 15-year-old children in order to respond to the following research problems:

1) What is the best fitting factor structure for each age group?
2) How does the factor structure of each age group compare with the six cognitive domains of the NEPSY-II?

Four-factor structures were extracted for 3- to 4-year-old, 5- to 6-year-old, and 7- to 15-year-old children. The following three sections review the factor solutions. The fourth section compares them to each other, and to the six cognitive domains of the NEPSY-II. The remaining sections discuss the considerations and clinical implications of the current study.

4.1. 3- to 4-year-old Factor Structure

In the 3- to 4-year-old age group, the subtests that loaded on the first, Language factor, were defined on one hand by verbal productions and recall, and on the other by understanding another person's perspective and emotions in their social context. Theory of Mind loaded highest on the factor. This subtest is divided into two parts: the first part is designed to assess understanding of another person's perspective, whereas the second part is designed to assess understanding of emotions related to different social situations. The first part demands verbal comprehension of figurative language (Korkman et al. 2008b), and a child can gain twice as many points from the first part compared to the second, nonverbal part, which may partly explain why the subtests loaded on the Language factor. The development of theory of mind is also linked on a general level to that of language: 3-year-old children's semantic and syntactical language abilities predict their performance in theory of mind tasks, but not vice versa (Astington & Jenkins, 1999); and 3- to 5-year-old children need to a reach a sufficient level of linguistic ability in order to pass false belief tasks (Jenkins & Astington, 1996).

Visuospatial skills and fine motor abilities described the subtests that loaded on the second, Visuospatial/Motor Functions factor. On the third, Motor Inhibition factor, loaded only a single subtest, Statue. The subtest, however, had a relatively high communality (.63) and, thus, its variance was explained by the factor solution better than that of any other subtest of the 3- to 4-year-olds.

Fast and/or accurate processing and precise use of pen characterized the subtests that loaded on the fourth, Processing Speed and Fine Motor Functions factor. Two out of the four subtests are timed, and one of them, accompanied by a third one, is scored on the basis of precise pen use. Comprehension of Instructions loaded highest on the factor. The 3- to 4-year-old version of this subtest bears a considerable similarity to a Conjunction Search task (Treisman & Gelade, 1980): in the former, a child is asked to point out rabbits, which are either big or small, blue or yellow, happy or sad, or have a combination of the aforementioned features; whereas, in the latter, a person is asked to search conjunctions of at least two features, such as size and colour, to distinguish a target. If a child performs well with pointing out the rabbits, the following task is to point out geometrical patterns of different shapes and colours. The latter task is accompanied by increasingly more difficult instructions, although few 3- to 4-year-olds manage to proceed to those of syntactical complexity. Speeded Naming, a Rapid Automatized Naming (RAN) -task (Wolf & Bowers, 1999), loaded second highest on the same factor. 3- to 4-year-old versions of Comprehension of Instructions and Speeded Naming are both serial tasks that have a strong visual aspect, and perhaps therefore loaded on this factor with two visuospatial subtests, instead of loading together with the subtests of Language domain, where they belong in the NEPSY-II.

4.2. 5- to 6-year-old Factor Structure

In the 5- to 6-year-old age group, Comprehension of Instructions and Visual Attention loaded highest on the first, Processing Speed and Working Memory factor. The 5- to 6-year-old versions of these subtests both have a higher amount of information to be processed than those of 3- to 4-year-old, and thus strain working memory. Visual Attention and Speeded Naming, which also loaded on the factor, are both timed, and thus require processing speed. As in the 3- to 4-year-old group, Comprehension of Instructions and Speeded Naming loaded also in this group on the same factor with two visuospatial subtests, this time with Visual Attention and Arrows.

Verbal recall defined the second, Language factor. The subtests that loaded on this factor required both immediate and delayed recall, freely as well as with the help of cues, with the content of recall varying from words and sentences to a whole narrative. Theory of Mind also loaded on the factor, again on the same one with verbal subtests, as it did in the 3- to 4-year-old group.

Fast learning of a new response set, inhibition of the old responses, and learning through repetition characterized the subtests that loaded on the third, Task Switching and Repetitive Learning factor. All the three subtests that loaded on the factor both share visual stimuli and strain working memory.

Fine motor skills and precise use of pen defined the fourth, Visuospatial/Motor Functions factor. Finger Tapping from the NEPSY-II Sensorimotor domain, a subtest that assesses finger dexterity, motor speed and motor programming (Korkman et al., 2008b), loaded negatively on the factor, whereas the remaining subtests from the Sensorimotor domain loaded on the factor positively. This appeared as problematic in terms of the validity of Finger Tapping in clinical assessment, as it may be reasonably assumed to measure at least broadly the same construct as the other subtests of the Sensorimotor domain.

Affect Recognition, designed to assess social perception by recognition of emotional affects from photos of children's faces (Korkman et al., 2008b), also loaded on the fourth, Visuospatial/Motor Functions factor. Recognition of affects from facial expressions is found to activate somatosensory cortex (Hussey & Safford, 2009), which indicates a possibility that Affect Recognition shared an aspect of sensory processing with the visuospatial and -motor subtests that otherwise characterized the factor. Thus, Affect Recognition might assess somewhat different qualities than the other subtest of the NEPSY-II Social Perception domain, Theory of Mind, which loaded together with verbal subtests.

4.3. 7- to-15-year-old Factor Structure

In the 7- to 15-year-old age group, Visuospatial perception and fine motor skills defined the first, Visuospatial/Motor Functions factor. The subtests that shared the visual stimuli of faces, either through visual search of faces, recognition of faces, or recall of names related with faces, however, loaded on the second, Facial Processing factor.

Verbal comprehension, processing, and recall characterized the third, Language factor. Comprehension of Instructions and Word List Interference loaded highest on the factor. These subtests not only demand verbal skills, but also strain working memory. Whereas Comprehension of Instructions loaded highest on the Language factor in this age group, in the two previous groups it loaded together with Speeded Naming and two visuospatial subtests. A possible underlying reason might be that Comprehension of Instructions assessed a somewhat different underlying construct in different age groups: whereas the 3- to 4-year-old version bears similarity to a visual Conjunction Search task (Treisman & Gelade, 1980), in the 5- to 17-year-old version the search task comes with syntactically increasingly difficult instructions (e.g. conditional "if…, then…" -statements), which put relatively more strain on verbal working memory. Theory of Mind also loaded on the factor, again together with the verbal subtests, as it did in the two previous age groups.

Rapid and resourceful production of concepts and patterns characterized the subtests that loaded on the fourth, Processing Speed and Fluency factor. All the four subtests that loaded on the factor are timed. Three of the subtests demand rapid production of concepts or patterns, and two of them require creative invention of super- and subordinate concepts. Speeded Naming from the NEPSY-II Language domain loaded in all the age groups not with the majority of the subtests that demand verbal skills, but together with the other subtests that require fast and accurate processing. Thus, although Speeded Naming and Phonological Processing, or, in more general terms, RAN and Phonological Awareness, are together strong predictors for early reading development and related difficulties (Wolf & Bowers, 1999), these two subtests may assess somewhat different aspects of this ability.

4.4. Comparison of the Factor Structures

Based on the review of the extracted factor structures, the structure of cognitive functions as measured by the NEPSY-II differed between the groups of 3- to 4-year-old, 5- to 6-

year-old, and 7- to 15-year-old children. Comparison of the factor structures revealed that, despite their differences, the age groups broadly shared three factors: Language, Visuospatial/Motor Functions, and Processing Speed (see Table 11). The set of subtests that loaded on these factors, however, differed from one group to another. The four-factor structures appeared as considerably different from the six cognitive domains of the NEPSY-II.

Table 11
Comparison of the 3- to 4-year-old, 5- to 6-year-old, and 7- to 15-year-old Factor Structures

3- to 4-year-olds	5- to 6-year-olds	7- to 15-year-olds
Language	Language	Language
Theory of Mind	Narrative Memory	Comprehension of Instructions
Narrative Memory	Memory for Names	Word List Interference
Sentence Repetition	Sentence Repetition	Phonological Processing
Phonological Processing	Word Generation	Narrative Memory
Body Part Naming	Theory of Mind	Theory of Mind
Affect Recognition		
Visuospatial/Motor Functions	Visuospatial/Motor Functions	Visuospatial/Motor Functions
Block Construction	Imitating Hand Positions	Picture Puzzles
Geometric Puzzles	Finger Tapping (negative loading)	Arrows
Imitating Hand Positions	Design Copying	Block Construction
	Finger Differentiation	Geometric Puzzles
	Visuomotor Precision	Imitating Hand Positions
	Affect Recognition	Design Copying
	Statue	Inhibition
		Memory for Designs
		Clocks
		Finger Differentiation
		Visuomotor Precision
Processing Speed and Fine Motor Functions	Processing Speed and Working Memory	Processing Speed and Fluency
Comprehension of Instructions	Comprehension of Instructions	Word Generation
Speeded Naming	Visual Attention	Design Fluency
Design Copying	Speeded Naming	Animal Sorting
Visuomotor Precision	Arrows	Speeded Naming
Motor Inhibition	Task Switching and Repetitive Learning	Facial Processing
Statue	Inhibition	Memory for Names
	Memory for Faces	Memory for Faces
	Memory for Designs	Visual Attention

Note. The factors are in a different order than in the original factor structures, whereas the subtests on each factor are in their original order from highest to lowest loading

The subtests that assessed aspects of either language or visuospatial and motor functions, originating both from within and beyond the respective NEPSY-II domains, had a tendency to load on their own factors. The tendency became clearer with age, and was most visible in the 7- to 15-year-old group. In this age group, the set of subtests that loaded on the Language and Visuospatial/Motor factors reached a reasonable level of internal covariance as measured by Cronbach's Alpha. In 3- to 4-year-old and 5- to 6-year-old groups, the sets of subtests that loaded on the Language factors reached a respective level of Alpha, whereas the subtests that loaded on the Visuospatial/Motor factors did not. The high level of internal covariance among the subtests that loaded on the Language factors may cast light on the previous findings (Stinnett et al., 2002; Jarrat, 2005), on the basis on which the internal structure of the NEPSY was proposed to be best described by one language-factor.

In addition to the Language and Visuospatial/Motor factors, the age groups shared a third, Processing Speed factor. Speeded Naming loaded on this factor in every group, instead of the Language factor, even though problems in the task predict reading difficulties (Wolf & Bowers, 1999), and the subtest accordingly belongs in the NEPSY-II Language domain. Otherwise, the set of subtests that loaded on the Processing Speed factor differed from one group to another: the 3- to 4-year-old Processing Speed and Fine Motor Functions factor included subtests that require the precise use of pen; the 5- to 6-year-old Processing Speed and Working Memory factor comprised subtests that strain working memory; and the 7- to 15-year-old the Processing Speed and Fluency factor consisted of subtests which, alongside processing speed, assess aspects of verbal and visual fluency. The loading of Speeded Naming on this, instead of the Language factor, might be explained by that processing speed and working memory are strongly related (Kyllonen & Christal, 1990) and rely more on shared attentional and executive resources than on domain-specific verbal and visual storage (Alloway, Gathercole & Pickering, 2006; Kane et al., 2004). The subtests that loaded on the Language factor, in contrast, might rely more on domain-specific verbal storage than on the shared attentional and executive resources.

Processing speed and working memory are closely related to reasoning ability, or fluid intelligence (Fry & Hale, 1996; 2000). Fluid intelligence is an ability of abstract and logical thinking and problem solving in novel tasks that do not depend on acquired knowledge (Cattell, 1963; Horn & Cattell, 1966). In terms of the relations between fluid intelligence, working memory, and processing speed (Fry & Hale, 1996), nearly half of age-related increase in the fluid intelligence is mediated by developmental changes in processing speed and working memory. Further, around three fourths of age-related improvement in working memory is mediated by developmental changes in processing speed. In addition to working memory and processing speed, fluid intelligence is also related to acquired general knowledge, which relies on domain-specific storage capacity (Kyllonen & Christal, 1990). Thus, the degree to which a subtest requires processing speed, working memory, fluid intelligence and general knowledge might have a significant impact on whether it loads together with subtests that require similar functions, such as, processing speed or working memory, or with subtests that share the same modality, whether auditory or visual.

The subtests from the NEPSY-II Attention and Executive Functioning domain scattered over factors more inconsistently than subtests from any other domain. In the 3- to 4-year-old group, only one subtest, Statue, exceeded the loading threshold of .30, and remained the single subtest on the factor. In the 5- to 6- and 7- to 15-year-old groups, these subtests loaded on three out of the four factors. On the basis of previous studies, the subtests from the Attention and Executive Functioning domain should be interpreted individually, instead of as representatives of their domain, as there is no support for the latter interpretation (Mosconi et al., 2008). Here one of the underlying reasons may be related to the character of attention and executive functions: although attention and executive functions are not modality-specific per se, there are no means to measure them without any sensory stimuli, which inevitably are modality-specific. Thus, the subtests designed to measure attention and executive functions correlate at most weakly together, and consequently fail to provide statistical support for their interpretation as components of the same construct.

Language, Visuospatial/Motor, and Processing Speed factors appeared in some aspects similar to the Verbal Comprehension, Visual Spatial and Processing Speed domains of WPPSI-IV and WISC-V. The similarities are interesting in the light that the NEPSY-II subtests are designed to assess primarily the individual components that make up the complex cognitive functions (Korkman et al., 2008b), whereas WPPSI-IV and WISC-V are designed to evaluate cognitive abilities not only on the level of basic components assessed by individual subtests (e.g. Block Design), but also on the level of domains (e.g. Visual Spatial), and full cognitive capacity. WPPSI-IV and WISC-V are developed with the help of factor analysis, and its results provide a basis for their domain structure of cognitive functioning (Canivez & Watkins, in press; Raiford & Coalson, 2014). The resulting domain structure of WPPSI-IV and WISC-V might have caught some regularities of cognitive functioning that factor analysis as a test development method is capable to catch, considering that the structure of cognitive functions as assessed by the NEPSY-II appeared as more similar to the former than to the its own six cognitive domains.

The NEPSY-II, however, is not designed with the help of factor analysis, and consequently the descriptive statistics for the factor solutions (see Tables 4, 6 and 8) remained low. The subtest communalities for each age group were mostly under .50, and went all the way down to .07 (7-15-year-old Finger Tapping). The cumulative percentages of variance explained by the factor structures were 52% for the 3- to 4-year-old, 44% for the 5- to 6-year-old, and 45% for the 7- to 15-year-old group. To summarize, the factor solutions explained at best around half of the variation in a given subtest, and roughly half of the variance within the age group. Thus, the factor structures are far from comprehensive solutions; instead, they might provide an impetus for the development of the psychometrical properties of the NEPSY-II.

4.5. Considerations

The current study examined the internal structure of the NEPSY-II by the means of EFA, which is descriptive in nature, and, thus, may be suitable at an early stage of psychometrical measurement model development (Hurley et al., 1997). However, at later stages of model development, when there is a psychometrically developed theory for hypothesized patterns of factor loadings, proper theory- and hypothesis testing might be better performed with confirmatory factor analysis (CFA) (Hurley et al., 1997). CFA would provide exact indices of the measurement model fit to the data, as well as of the level of age-invariance between age groups.

For another thing, age is an important factor in brain and cognitive development, but so is gender, which was beyond the scope of this study. There are, however, considerable gender differences in brain development (Giedd, 2008; Lenroot et al., 2007) and in cognitive development (Vuontela et al., 2003). Thus it is reasonable to expect the factor structures to differ between groups not only on the basis of age, but also on the basis of gender. Therefore, not only the level of age-invariance, but also that of gender-invariance could be tested in the future.

4.6. Clinical Implications and Concluding Remarks

The internal structure of the NEPSY-II, as examined by EFA, differed between the groups of 3- to 4-year-old, 5- to 6-year-old, and 7- to 15-year-old children. Comparison of the extracted factor structures revealed that, despite their differences, the age groups broadly shared three factors: Language, Visuospatial/Motor Functions, and Processing Speed. The set of subtests that loaded on these factors, however, differed from one group to another. The extracted factor structures appeared in some aspects more similar to the domain structure of WPPSI-IV and WISC-V, than to the six cognitive domains of the NEPSY-II.

These findings may be related to the framework of thinking that the structure of adult cognitive domains, from the basis of which the NEPSY-II was also developed, are the result of a developmental process (Karmiloff-Smith, 1998). As such, the adult domain structure may essentially differ from that of children, whose cognitive functions are still in the process of development. This might explain some of the differences between the extracted factor structures and the NEPSY-II cognitive domains. Further, there may be some domain-relevant mechanisms already in place in childhood, which are more inclined than others to process certain types of input, and as a result of repetitive processing provide a basis for domain-specific mechanisms, such as, language, to emerge (Karmiloff-Smith, 1998). Meanwhile, the set of mechanisms related to each domain may fluctuate in this process of development, which might also explain some of the differences in factor structures between the age groups.

The findings are relevant in regard to the interpretation of individual test results in a clinical setting. For one thing, some of the subtests (e.g., Narrative Memory and Theory of Mind) loaded on the same factor (Language) in all the age groups, whereas others (e.g. Comprehension of Instructions) loaded differently from one age group to another. The former may be interpreted to consistently reflect the same underlying construct, whereas the latter might reflect somewhat different constructs at distinct points of age. In a clinical setting, the individual test results can be compared to the earlier ones, if there are such, to evaluate the development of cognitive abilities. The subtests that appear to reflect the same construct at different points of age may be straightforwardly compared to earlier ones, whereas the subtests that seem to reflect somewhat different constructs might require more thorough consideration.

For another thing, as a rule of thumb suggested in the manual, there should be difficulties in performance in at least two subtests within a domain before one can draw any clinical conclusions (Korkman et al., 2008b). However, there could be occasions when difficulties in one or two subtests emerge in different domains. In this case, the framework of neuropsychological research can offer some guidelines for clinical interpretation of the test results. However, psychometrical research on the relations between the subtests may also cast light on how the problems in subtest performance are related, and thus provide a valuable source of information in clinical decision-making. The now reported psychometrical properties might be considered also in the development of the following version of the instrument, the NEPSY-III, thus making the comprehensive test an even more valuable tool in understanding the underlying structure of children's cognitive development.

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Appendices

Appendix 1
Parent Basic- and Further Education

Highest Completed Education (%)						
		Father				Total
		Basic	Lower Vocational	Higher Vocational	University / Polytechnic	
Mother	Basic	1	2	0	1	4
	Lower Vocational	4	8	3	2	17
	Higher Vocational	3	11	14	8	36
	University / Polytechnic	2	6	10	25	43
Total		9	27	27	36	100

Appendix 2

3- to 4-year-old Subtest Intercorrelations

Subtest		ST	VA	BP	CI	PH	SN	WG	NM	SR	IH	VP	AR	TM	BC	DC
Statue	ST															
Visual Attention	VA	.14														
Body Part Naming	BP	.22**	.13													
Comprehension of Instructions	CI	.13	.17*	**.37****												
Phonological Processing	PH	.09	.21**	.22**	.29**											
Speeded Naming	SN	**.31****	.17*	.17*	**.39****	.09										
Word Generation	WG	**.36****	.14*	.29**	**.33****	.15*	.24**									
Narrative Memory	NM	.29**	.15*	**.33****	.27**	.24**	.19**	**.38****								
Sentence Repetition	SR	**.30****	.15*	**.32****	**.41****	**.34****	**.33****	**.37****	**.42****							
Imitating Hand Positions	IH	.23**	.19**	.22**	.17*	.10	.17*	.25**	.23**	.16*						
Visuomotor Precision	VP	.14	.28**	.18**	.19**	.08	.15*	.08	.13	.10	.08					
Affect Recognition	AR	**.32****	.17*	.20**	**.32****	.27**	**.33****	.28**	**.38****	**.30****	.13	.13				
Theory of Mind	TM	.16*	.08	**.30****	.22**	.22**	.13	.25**	**.42****	**.40****	.21**	.06	**.30****			
Block Construction	BC	.17*	.17*	.18*	**.35****	.10	.29**	**.33****	.23**	.29**	**.36****	.15*	.14*	.17*		
Design Copying	DC	.18**	.22**	.27**	**.34****	.19**	**.32****	.28**	.18**	.26**	**.32****	.28**	.27**	.18**	.29**	
Geometric Puzzles	GP	.13	.20**	.20**	**.37****	.15*	.22**	.24**	.15*	.24**	.29**	.23**	.22**	.14*	**.49****	**.33****

Correlations >.30 are in bold. ** $p < .01$. * $p < .05$.

Appendix 3

5- to 6-year-old Subtest Intercorrelations

Subtest		AA	DF	IN	ST	VA	CI	PH	SN	WG	MD	MF	MN	NM	SR	FT	IH	VP	FD	AR	TM	AW	BC	DC
Auditory Attention	AA																							
Design Fluency	DF	**.34****																						
Inhibition	IN	**.33****	.18**																					
Statue	ST	**.32****	.23**	.12																				
Visual Attention	VA	.21**	.18**	.17*	.15*																			
Comprehension of Instructions	CI	**.32****	.26**	.25**	**.32****	**.41****																		
Phonological Processing	PH	.25**	.22**	.22**	.05	.19**	**.34****																	
Speeded Naming	SN	**.41****	.29**	**.35****	.19**	**.34****	**.43****	.28**																
Word Generation	WG	**.35****	.21**	.23**	.10	.20**	**.32****	.17*	.29**															
Memory for Designs	MD	.15*	.18**	**.34****	.14*	.22**	**.37****	.15*	.23**	.16*														
Memory for Faces	MF	.25**	.19**	.23**	.10	.22**	.17*	.13*	.08	.16*	**.30****													
Memory for Names	MN	.24**	.17**	.27**	.08	.07	.26**	**.38****	.27**	.28**	.22**	.26**												
Narrative Memory	NM	.29**	.29**	.10	.16*	.15*	**.33****	**.31****	**.33****	**.40****	.09	.15*	**.46****											
Sentence Repetition	SR	**.31****	.23**	.14*	.29**	.19**	**.50****	.29**	.27**	**.38****	.20**	.04	.26**	**.50****										
Finger Tapping	FT	-.16*	-.18**	-.17**	-.27**	-.12	-.25**	-.22**	-.19**	-.14*	-.04	-.09	-.10	-.23**	-.20**									
Imitating Hand Positions	IH	.21**	.18**	.28**	.25**	.13	.29**	.21**	.17*	.21**	.25**	.20**	.14*	**.30****	.28**	**-.32****								
Visuomotor Precision	VP	.19**	.20**	**.31****	.26**	.15*	.21**	.12	.26**	.18**	.24**	.24**	.22**	.17*	.21**	-.13	**.35****							
Finger Differentiation	FD	.13	.12	.16*	.14*	.26**	.21**	.19**	.07	.11	.12	.08	.06	.04	.16*	-.21**	.24**	.13						
Affect Recognition	AR	.20**	.09	.26**	.13	.20**	.21**	.16*	.06	.13	.14*	.19**	.08	.14*	.15*	-.20**	.20**	.29**	.22**					
Theory of Mind	TM	**.38****	.26**	.16*	.25**	.21**	**.46****	**.37****	**.32****	**.34****	.22**	.25**	.28**	**.41****	**.31****	-.19**	.23**	.25**	.13	.16*				
Arrows	AW	.29**	.24**	.26**	.25**	.23**	**.40****	.23**	**.30****	.19**	.20**	.25**	.18**	.15*	.26**	-.15*	.15*	.27**	.24**	.16*	.21**			
Block Construction	BC	.21**	.17*	**.34****	.20**	.21**	**.30****	.26**	.22**	.21**	**.36****	.15*	.16*	.15*	.25**	-.16*	.26**	.26**	.13	.17*	**.31****	.27**		
Design Copying	DC	.25**	.21**	**.36****	.22**	**.34****	**.33****	.28**	**.33****	.24**	**.31****	.22**	.16*	.17*	.25**	-.24**	**.32****	**.36****	**.36****	.25**	.17*	**.38****	**.33****	
Geometric Puzzles	GP	.19**	.16*	.20**	.22**	.24**	.25**	.20**	.29**	.23**	.16*	.15*	.10	.22**	.14*	-.21**	.19**	.20**	.10	.04	.26**	.25**	**.30****	**.30****

Correlations >.30 are in bold. ** $p < .01$. * $p < .05$.

Appendix 4

7- to 15-year-old Subtest Intercorrelations

Subtest		AS	AA	CL	DF	IN	VA	CI	PH	SN	WG	MD	MF	MN	NM	WL	FT	IH	VP	FD	AR	TM	AW	BC	DC	GP
Animal Sorting	AS																									
Auditory Attention	AA	.17**																								
Clocks	CL	.16**	.29**																							
Design Fluency	DF	.28**	.26**	.22**																						
Inhibition	IN	.21**	**.36****	**.32****	.28**																					
Visual Attention	VA	.25**	.19**	.17**	.17**	.24**																				
Comprehension of Instructions	CI	.29**	.27**	**.34****	.25**	**.41****	.20**																			
Phonological Processing	PH	.28**	**.32****	**.39****	.22**	**.44****	.24**	**.52****																		
Speeded Naming	SN	.18**	**.31****	.27**	**.30****	**.42****	.17**	**.33****	**.35****																	
Word Generation	WG	**.36****	**.33****	.26**	**.37****	**.34****	**.32****	**.36****	**.30****	**.33****																
Memory for Designs	MD	.25**	.15**	.26**	.20**	**.35****	.28**	**.32****	.29**	.13**	.23**															
Memory for Faces	MF	.12**	.07	.07	.03	.12**	**.33****	.14**	.20**	.07	.11*	.20**														
Memory for Names	MN	.21**	.23**	.27**	.07	.24**	**.34****	**.37****	**.41****	.22**	**.36****	**.36****	**.35****													
Narrative Memory	NM	**.32****	.24**	**.31****	.23**	.28**	.20**	**.43****	**.37****	.23**	**.41****	.24**	.14**	**.34****												
Word List Interference	WL	.27**	.26**	**.32****	.23**	**.40****	.19**	**.52****	**.47****	.29**	**.35****	.19**	.09*	**.30****	**.40****											
Finger Tapping	FT	-.04	-.09*	-.17**	-.10*	-.18**	-.05	-.10*	-.10*	-.14**	-.13**	-.10*	-.10*	-.07	-.11*	-.15**										
Imitating Hand Positions	IH	.18**	**.35****	**.34****	.15**	**.31****	.18**	.29**	**.34****	.22**	.17**	.25**	.20**	.21**	.26**	.29**	-.23**									
Visuomotor Precision	VP	.11*	.20**	.13**	.15**	.23**	.15**	.12**	.15**	.21**	.11*	.18**	.13**	.18**	.08	.15**	-.13**	.20**								
Finger Differentiation	FD	.14**	.13**	.23**	.06	.20**	.09*	.24**	**.31****	.09*	.11*	.19**	.12**	.18**	.15**	.22**	-.12**	**.36****	.07							
Affect Recognition	AR	.16**	.19**	.26**	.10*	.25**	.21**	.28**	**.33****	.15**	.19**	.17**	.18**	.18**	.18**	.22**	-.14**	.24**	.19**	.15**						
Theory of Mind	TM	**.32****	**.31****	**.36****	.17**	**.34****	.29**	**.42****	**.38****	.22**	**.32****	.29**	.21**	**.40****	**.45****	**.37****	-.14**	**.36****	.18**	.24**	**.34****					
Arrows	AW	.14**	.22**	.28**	.19**	.29**	.18**	.24**	**.32****	.13**	.15**	.20**	.08	.14**	.24**	.21**	-.17**	.26**	.19**	.21**	.17**	.27**				
Block Construction	BC	.28**	.22**	.25**	**.32****	**.42****	.22**	**.31****	.27**	**.30****	.25**	**.38****	.06	.11*	.29**	.28**	-.16**	.28**	.22**	.23**	.21**	**.32****	.28**			
Design Copying	DC	.19**	**.33****	**.37****	.21**	**.34****	.21**	.29**	**.38****	.28**	.22**	.29**	.19**	.27**	.28**	.25**	-.10*	**.30****	.28**	.15**	.22**	**.37****	.29**	**.37****		
Geometric Puzzles	GP	.26**	.22**	**.32****	.24**	**.37****	.22**	**.35****	**.40****	.27**	.26**	**.31****	.10*	.17**	.29**	**.33****	-.21**	**.34****	.11*	.28**	.26**	**.30****	**.31****	**.39****	**.31****	
Picture Puzzles	PP	**.33****	.29**	**.32****	.21**	**.38****	**.34****	.28**	**.38****	.20**	**.30****	**.42****	.24**	.26**	.28**	**.32****	-.12**	**.36****	.22**	.19**	.26**	**.38****	**.49****	**.37****	**.41****	**.40****

Correlations >.30 are in bold. ** $p < .01$. * $p < .05$.

Appendix 5

7- to 9-year-old Subtest Intercorrelations

Subtest		AS	AA	CL	DF	IN	VA	CI	PH	SN	WG	MD	MF	MN	NM	WL	FT	IH	VP	FD	AR	TM	AW	BC	DC	GP
Animal Sorting	AS																									
Auditory Attention	AA	$.13^{*}$																								
Clocks	CL	$.14^{*}$	$.19^{**}$																							
Design Fluency	DF	$.23^{**}$	$.27^{**}$	$.24^{**}$																						
Inhibition	IN	$.19^{**}$	$\mathbf{.34}^{**}$	$.28^{**}$	$.25^{**}$																					
Visual Attention	VA	$.22^{**}$	$.21^{**}$	$.12$	$.17^{**}$	$.19^{**}$																				
Comprehension of Instructions	CI	$.19^{**}$	$.20^{**}$	$.27^{**}$	$.22^{**}$	$\mathbf{.37}^{**}$	$.14^{*}$																			
Phonological Processing	PH	$.26^{**}$	$.25^{**}$	$\mathbf{.39}^{**}$	$.26^{**}$	$\mathbf{.46}^{**}$	$.18^{**}$	$\mathbf{.45}^{**}$																		
Speeded Naming	SN	$.20^{**}$	$\mathbf{.35}^{**}$	$\mathbf{.33}^{**}$	$.27^{**}$	$\mathbf{.44}^{**}$	$.25^{**}$	$\mathbf{.34}^{**}$	$\mathbf{.44}^{**}$																	
Word Generation	WG	$\mathbf{.35}^{**}$	$\mathbf{.33}^{**}$	$.21^{**}$	$\mathbf{.31}^{**}$	$.28^{**}$	$\mathbf{.31}^{**}$	$\mathbf{.34}^{**}$	$.28^{**}$	$\mathbf{.33}^{**}$																
Memory for Designs	MD	$.25^{**}$	$.10$	$.19^{**}$	$.17^{**}$	$.24^{**}$	$\mathbf{.30}^{**}$	$.26^{**}$	$.23^{**}$	$.10$	$.21^{**}$															
Memory for Faces	MF	$.19^{**}$	$.11$	$.07$	$.00$	$.06$	$.25^{**}$	$.10$	$.17^{**}$	$.05$	$.14^{*}$	$.24^{**}$														
Memory for Names	MN	$.23^{**}$	$.20^{**}$	$.19^{**}$	$.03$	$.19^{**}$	$.28^{**}$	$\mathbf{.31}^{**}$	$\mathbf{.31}^{**}$	$.23^{**}$	$\mathbf{.34}^{**}$	$\mathbf{.30}^{**}$	$\mathbf{.38}^{**}$													
Narrative Memory	NM	$.24^{**}$	$.15^{*}$	$.21^{**}$	$.08$	$.24^{**}$	$.17^{**}$	$\mathbf{.43}^{**}$	$\mathbf{.33}^{**}$	$.21^{**}$	$\mathbf{.32}^{**}$	$.19^{**}$	$.15^{*}$	$.28^{**}$												
Word List Interference	WL	$.23^{**}$	$.22^{**}$	$.23^{**}$	$.29^{**}$	$\mathbf{.42}^{**}$	$.19^{**}$	$\mathbf{.47}^{**}$	$\mathbf{.40}^{**}$	$\mathbf{.30}^{**}$	$\mathbf{.35}^{**}$	$.07$	$.08$	$.20^{**}$	$\mathbf{.33}^{**}$											
Finger Tapping	FT	$.02$	$-.16^{**}$	$-.09$	$-.04$	$-.14^{*}$	$-.03$	$-.09$	$-.14^{*}$	$-.14^{*}$	$-.13^{*}$	$-.04$	$-.09$	$-.07$	$-.11$	$-.16^{**}$										
Imitating Hand Positions	IH	$.22^{**}$	$\mathbf{.32}^{**}$	$.29^{**}$	$.16^{*}$	$.28^{**}$	$.19^{**}$	$.23^{**}$	$\mathbf{.32}^{**}$	$.21^{**}$	$.18^{**}$	$.23^{**}$	$.21^{**}$	$.20^{**}$	$.24^{**}$	$.28^{**}$	$\mathbf{-.35}^{**}$									
Visuomotor Precision	VP	$.10$	$.25^{**}$	$.09$	$.17^{**}$	$.21^{**}$	$.12$	$.04$	$.12^{*}$	$.26^{**}$	$.12$	$.20^{**}$	$.17^{**}$	$.23^{**}$	$.04$	$.11$	$-.14^{*}$	$.16^{*}$								
Finger Differentiation	FD	$.22^{**}$	$.06$	$.20^{**}$	$.01$	$.19^{**}$	$.09$	$.23^{**}$	$\mathbf{.31}^{**}$	$.06$	$.09$	$.14^{*}$	$.08$	$.19^{**}$	$.15^{*}$	$.16^{**}$	$-.08$	$.24^{**}$	$.00$							
Affect Recognition	AR	$.08$	$.10$	$.17^{**}$	$.05$	$.17^{**}$	$.16^{*}$	$.12^{*}$	$.19^{**}$	$.10$	$.20^{**}$	$.13^{*}$	$.20^{**}$	$.12$	$.08$	$.13^{*}$	$-.16^{*}$	$.23^{**}$	$.14^{*}$	$.13^{*}$						
Theory of Mind	TM	$\mathbf{.35}^{**}$	$\mathbf{.32}^{**}$	$.22^{**}$	$.09$	$.26^{**}$	$.23^{**}$	$\mathbf{.30}^{**}$	$.28^{**}$	$.22^{**}$	$.28^{**}$	$.26^{**}$	$.20^{**}$	$.25^{**}$	$\mathbf{.42}^{**}$	$\mathbf{.31}^{**}$	$-.18^{**}$	$\mathbf{.31}^{**}$	$.19^{**}$	$.23^{**}$	$.27^{**}$					
Arrows	AW	$.13^{*}$	$.26^{**}$	$\mathbf{.30}^{**}$	$.19^{**}$	$.26^{**}$	$.19^{**}$	$.16^{*}$	$\mathbf{.30}^{**}$	$.17^{**}$	$.10$	$.23^{**}$	$.06$	$.14^{*}$	$.14^{*}$	$.13^{*}$	$-.09$	$.26^{**}$	$.22^{**}$	$.20^{**}$	$.08$	$.27^{**}$				
Block Construction	BC	$\mathbf{.31}^{**}$	$.20^{**}$	$.25^{**}$	$.26^{**}$	$\mathbf{.41}^{**}$	$.24^{**}$	$.29^{**}$	$.25^{**}$	$\mathbf{.30}^{**}$	$.20^{**}$	$\mathbf{.36}^{**}$	$.09$	$-.06$	$.28^{**}$	$\mathbf{.32}^{**}$	$-.13^{*}$	$.24^{**}$	$.15^{*}$	$.18^{**}$	$.09$	$\mathbf{.34}^{**}$	$\mathbf{.38}^{**}$			
Design Copying	DC	$.23^{**}$	$\mathbf{.34}^{**}$	$.29^{**}$	$.20^{**}$	$\mathbf{.33}^{**}$	$.23^{**}$	$.21^{**}$	$\mathbf{.32}^{**}$	$.25^{**}$	$.18^{**}$	$\mathbf{.34}^{**}$	$.21^{**}$	$.27^{**}$	$.19^{**}$	$.17^{**}$	$-.05$	$.23^{**}$	$\mathbf{.37}^{**}$	$.05$	$.12$	$\mathbf{.38}^{**}$	$\mathbf{.36}^{**}$	$\mathbf{.33}^{**}$		
Geometric Puzzles	GP	$.23^{**}$	$.22^{**}$	$\mathbf{.30}^{**}$	$.23^{**}$	$\mathbf{.35}^{**}$	$.20^{**}$	$.25^{**}$	$\mathbf{.38}^{**}$	$.28^{**}$	$.28^{**}$	$.20^{**}$	$.07$	$.04$	$.23^{**}$	$\mathbf{.33}^{**}$	$-.16^{*}$	$.29^{**}$	$.09$	$.25^{**}$	$.20^{**}$	$.26^{**}$	$\mathbf{.33}^{**}$	$\mathbf{.34}^{**}$	$.22^{**}$	
Picture Puzzles	PP	$\mathbf{.35}^{**}$	$.24^{**}$	$.26^{**}$	$.22^{**}$	$.25^{**}$	$.23^{**}$	$.14^{*}$	$\mathbf{.30}^{**}$	$.17^{**}$	$.29^{**}$	$\mathbf{.38}^{**}$	$.24^{**}$	$.15^{*}$	$.19^{**}$	$.25^{**}$	$-.05$	$\mathbf{.30}^{**}$	$.20^{**}$	$.11$	$.17^{**}$	$\mathbf{.32}^{**}$	$\mathbf{.50}^{**}$	$\mathbf{.34}^{**}$	$\mathbf{.41}^{**}$	$\mathbf{.33}^{**}$

Correlations >.30 are in bold. ** $p < .01$. * $p < .05$.

Appendix 6

10- to 15-year-old Subtest Intercorrelations

Subtest		AS	AA	CL	DF	IN	VA	CI	PH	SN	WG	MD	MF	MN	NM	WL	FT	IH	VP	FD	AR	TM	AW	BC	DC	GP
Animal Sorting	AS																									
Auditory Attention	AA	.21**																								
Clocks	CL	.17**	**.40****																							
Design Fluency	DF	**.32****	.25**	.21**																						
Inhibition	IN	.21**	**.38****	**.36****	**.31****																					
Visual Attention	VA	.28**	.17**	.20**	.16*	.28**																				
Comprehension of Instructions	CI	**.39****	**.35****	**.43****	.29**	**.45****	.25**																			
Phonological Processing	PH	**.30****	**.39****	**.39****	.19**	**.41****	**.30****	**.59****																		
Speeded Naming	SN	.16*	.29**	.22**	**.33****	**.40****	.10	**.32****	.24**																	
Word Generation	WG	**.36****	**.34****	**.31****	**.44****	**.40****	**.33****	**.38****	**.32****	**.34****																
Memory for Designs	MD	.25**	.20**	**.32****	.23**	**.44****	.26**	**.37****	**.34****	.16*	.24**															
Memory for Faces	MF	.06	.02	.07	.05	.16*	**.41****	.18**	.23**	.10	.08	.14*														
Memory for Names	MN	.19**	.27**	**.34****	.11	.28**	**.39****	**.43****	**.50****	.20**	**.37****	**.40****	**.34****													
Narrative Memory	NM	**.39****	**.31****	**.42****	**.36****	**.31****	.22**	**.43****	**.41****	.23**	**.50****	.28**	.12	**.37****												
Word List Interference	WL	**.30****	**.31****	**.41****	.17**	**.38****	.19**	**.57****	**.53****	**.30****	**.35****	.29**	.10	**.38****	**.46****											
Finger Tapping	FT	-.08	-.01	-.22**	-.15*	-.19**	-.06	-.08	-.04	-.13*	-.12	-.14*	-.10	-.05	-.10	-.14*										
Imitating Hand Positions	IH	.13*	**.38****	**.40****	.14*	**.33****	.17**	**.36****	**.36****	.25**	.17**	.27**	.17**	.23**	.27**	.32**	-.09									
Visuomotor Precision	VP	.14*	.16*	.17**	.13*	.25**	.18**	.22**	.18**	.14*	.10	.16*	.07	.13*	.13*	.20**	-.08	.23**								
Finger Differentiation	FD	.08	.21**	.28**	.11	.22**	.09	.27**	**.32****	.12	.13*	.23**	.15*	.18**	.15*	.27**	-.14*	**.49****	.15*							
Affect Recognition	AR	.23**	.28**	**.35****	.15*	**.32****	.27**	**.43****	**.48****	.21**	.18**	.21**	.16*	.25**	.27**	.30**	-.10	.26**	.24**	.19**						
Theory of Mind	TM	.29**	**.30****	**.51****	.24**	**.41****	**.36****	**.54****	**.48****	.21**	**.36****	**.31****	.22**	**.53****	**.49****	**.44****	-.07	**.40****	.16*	.27**	**.41****					
Arrows	AW	.15*	.19**	.27**	.18**	**.31****	.17**	**.32****	**.34****	.09	.22**	.16*	.10	.12	**.33****	**.30****	-.24**	.26**	.16*	.24**	.26**	.27**				
Block Construction	BC	.25**	.25**	.27**	**.38****	**.42****	.21**	**.33****	.29**	**.31****	**.30****	**.40****	.02	.23**	**.30****	.25**	-.17**	**.32****	**.31****	.28**	**.34****	**.31****	.19**			
Design Copying	DC	.14*	**.33****	**.46****	.22**	**.35****	.18**	**.38****	**.44****	**.33****	.27**	.24**	.16*	.28**	**.37****	**.32****	-.13*	**.36****	.17**	.25**	**.32****	**.36****	.23**	**.40****		
Geometric Puzzles	GP	.29**	.22**	**.36****	.26**	**.38****	.24**	**.45****	**.43****	.28**	.25**	**.41****	.12	.27**	**.35****	**.34****	-.25**	**.39****	.14*	**.33****	**.31****	**.35****	.29**	**.44****	**.40****	
Picture Puzzles	PP	**.30****	**.35****	**.37****	.19**	**.49****	**.43****	**.43****	**.46****	.23**	**.31****	**.45****	.22**	**.33****	**.37****	**.40****	-.17**	**.42****	.25**	.29**	**.36****	**.44****	**.47****	**.39****	**.42****	**.46****

Correlations >.30 are in bold. ** $p < .01$. * $p < .05$.

Appendix 7
7- to 9-year-old Subtest Factor Loadings in a Five-Factor Structure

Subtest	Factor					Communality
	Name Recall and Face Recognition	Verbal Functioning and Working Memory	Visuospatial/Motor Functioning	Processing Speed	Productivity	
Memory for Names	**.96**	.22	-.15			.99
Memory for Faces	**.34**		.19		.17	.23
Phonological Processing		**.66**				.51
Comprehension of Instructions		**.59**	-.15		.23	.47
Inhibition		**.51**		.27		.46
Word List Interference		**.49**	-.11		.30	.42
Clocks		**.43**	.18			.29
Finger Differentiation		**.42**	.14	-.29		.26
Geometric Puzzles	-.17	**.37**	.25		.13	.35
Narrative Memory	.10	**.35**		-.15	.34	.35
Imitating Hand Positions		**.30**	.26			.26
Finger Tapping		-.21				.06
Picture Puzzles			**.62**		.20	.50
Arrows		.20	**.61**		-.19	.47
Design Copying	.12		**.46**	.28		.43
Block Construction	-.29	.21	**.41**		.25	.45
Memory for Designs	.18		**.40**		.21	.33
Affect Recognition		.11	.13		.12	.08
Speeded Naming		.43	-.12	**.47**		.49
Auditory Attention		.15	.11	**.42**		.32
Visuomotor Precision	.16		.23	**.41**		.28
Design Fluency	-.14	.13		**.32**	.22	.25
Word Generation	.12	.10	-.13	.23	**.56**	.48
Animal Sorting			.19		**.47**	.33
Theory of Mind		.17	.29		**.31**	.36
Visual Attention	.15		.15	.15	**.30**	.24
Eigenvalue	6.65	1.68	1.58	1.37	1.34	
% of Variance Explained	25.56	6.47	6.06	5.28	5.15	
Cumulative %	25.56	32.03	38.08	43.37	48.52	

Factor loadings >.30 are in bold

Appendix 8
7- to 9-year-old Factor Intercorrelations

Factor	Name Recall and Face Recognition	Verbal Functioning and Working Memory	Visuospatial/Motor Functioning	Processing Speed
Name Recall and Face Recognition				
Verbal Functioning and Working Memory	.12			
Visuospatial/Motor Functioning	.22	**.37**		
Processing Speed	.05	.24	.23	
Productivity	.22	**.43**	**.31**	.20

Correlations >.30 are in bold.

Appendix 9

10- to 15-year-old Subtest Factor Loadings in a Five-Factor Structure

Subtest	Factor					Communality
	Verbal Functioning	Face Recognition	Productivity	2D Visuospatial Functioning	3D Visuospatial and Motor Functioning	
Phonological Processing	**.67**	.14				.58
Word List Interference	**.64**		.11	.10		.48
Comprehension of Instructions	**.63**		.14			.57
Theory of Mind	**.56**	.22				.53
Clocks	**.51**				.15	.40
Memory for Names	**.50**	.40		-.22		.54
Narrative Memory	**.45**		.41	.15	-.12	.51
Auditory Attention	**.37**		.15		.17	.29
Affect Recognition	**.36**	.13		.10	.15	.30
Design Copying	**.35**				.32	.37
Visual Attention	-.12	**.76**	.15			.61
Memory for Faces		**.53**				.28
Word Generation	.18	.12	**.63**			.56
Design Fluency			**.59**		.21	.44
Animal Sorting	.15	.12	**.40**			.28
Arrows	.16			**.79**	-.19	.63
Picture Puzzles	.14	.34		**.40**	.22	.61
Finger Tapping				-.27	-.15	.12
Block Construction			.23		**.60**	.51
Geometric Puzzles	.22			.16	**.38**	.43
Imitating Hand Positions	.36		-.17	.12	**.37**	.42
Memory for Designs	.13	.24			**.35**	.34
Inhibition	.16	.13	.21	.15	**.34**	.45
Speeded Naming	.17		.29		**.31**	.28
Finger Differentiation	.29		-.20	.13	**.31**	.29
Visuomotor Precision		.10			.26	.14
Eigenvalue	8.22	1.55	1.51	1.30	1.12	
% of Variance Explained	31.60	5.95	5.82	4.99	4.30	
Cumulative %	31.60	37.55	43.37	48.36	52.66	

Factor loadings >.30 are in bold

Appendix 10

10- to 15-year-old Factor Intercorrelations

Factor	Verbal Functioning	Face Recognition	Productivity	2D Visuospatial Functioning
Verbal Functioning				
Face Recognition	**.41**			
Productivity	**.34**	.19		
2D Visuospatial Functioning	**.37**	.19	.22	
3D Visuospatial and Motor Functioning	**.44**	.21	.27	**.40**

Correlations >.30 are in bold.