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CHILDREN'S NEUROCOGNITIVE PERFORMANCE:

RELATIONSHIPS WITH CULTURE, MEDIA USE, AGE, AND EMOTION RECOGNITION

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ACADEMIC DISSERTATION

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ABSTRACT

Neurocognitive functions, such as attention/executive functions, language, memory/learning, sensorimotor functions, social perception, and visuospatial processing, gradually develop as a child grows. This happens following brain maturation, but also in close relationships with the environment and background of the child. Thus, background and environmental variables may explain variation in neurocognitive performance. In order to understand atypical performance on neurocognitive tasks, information regarding typical neurocognitive development is needed. The aim of the present thesis was to explore the relationship among background and environmental variables and neurocognitive performance in typically developing children.

The present thesis consists of three empirical studies exploring the relationships among background, environmental, and neurocognitive variables in a large sample of 3–15-year-old children from three countries. Study I compared the cross-sectional development of neurocognitive functions among 2,745 children from Finland, Italy, and the United States, aged 3–15, thus investigating the relationship between cultures and neurocognition. Study II investigated the relationship between media use—that is, time spent watching television (TV), using the computer, or reading—and neurocognitive functions in 381 children, aged 5–12 years, from the United States. Study III investigated more closely one neurocognitive function—the ability to recognize emotional expressions—in 370 3–6-year-old Finnish children. The developmental sequence of the function, as well as its relationship with other neurocognitive functions, was explored. In all three studies, standardization data from the comprehensive and international child neuropsychological assessment, NEPSY-II, was used.

Neurocognitive performance proved to be related to all the assessed variables in all three studies. In Study I, cultural differences emerged for most neurocognitive functions, especially in younger children, with somewhat different developmental pathways in the three countries. In Study II, media use was also significantly related to neurocognitive performance in children from the United States. TV watching was negatively related to neurocognition, while computer use was positively related to some neurocognitive functions. Reading was positively related to some functions in younger children and when maternal education was lower. The emotion recognition ability, investigated in in Study III, showed a specific developmental pattern in Finnish preschool-aged children and proved to be related to other neurocognitive functions, especially language.

In all, the findings of the present thesis suggest that neurocognitive functions develop in close relation with the environment and background of the child. Cultural and media use habit differences, in addition to age and parental education level, may explain some of the variation in neurocognitive

performance appearing during pediatric clinical assessments. Further, deficits in neurocognitive functions may partly explain deficits in other functions, for example, emotion recognition ability. The present findings have implications for families and multicultural assessments of children in different countries. One specific implication involves guidelines for assessing English- and Swedish-speaking children in Finland. In all, the three studies add new information to the neuropsychology research fields of cultural, media, and social function studies.

TIIVISTELMÄ

Neurokognitiiviset toiminnot, kuten esimerkiksi tarkkaavuus ja toiminnanohjaus, kielelliset toiminnot, muisti ja oppiminen, sensomotoriset toiminnot, sosiaalinen havaitseminen sekä visuospatiaaliset toiminnot kehittyvät lapsen kasvaessa. Tämä tapahtuu aivojen kehityksen seurauksena, mutta myös suhteessa lapsen taustaan ja ympäristöön. Tausta- ja ympäristötekijät saattavat näin ollen selittää vaihtelua neurokognitiivisessa suoriutumisessa. Neurokognitiivisten vaikeuksien ymmärtämiseksi tarvitaan tietoa tyypillisestä neurokognitiivisestä kehityksestä. Väitöskirjan tavoitteena oli tutkia tyypillisesti kehittyvien lasten neurokognitiivisen suoriutumisen ja tausta- ja ympäristötekijöiden yhteyttä.

Väitöskirja koostuu kolmesta osatutkimuksesta, joissa tarkastellaan ympäristö-, tausta- ja neurokognitiivisten tekijöiden yhteyttä 3–15 vuotiailla lapsilla kolmesta maasta. Osatutkimuksessa I tutkittiin kulttuurin ja neurokognition yhteyttä vertaamalla 2745:n suomalaisen, italialaisen ja yhdysvaltalaisen lapsen neurokognitiivista suoriutumista poikkileikkausasetelmassa. Osatutkimuksessa II selvitettiin mediakäytön, eli tv:n katselun, tietokoneen käytön sekä lukemisen yhteyttä neurokognitiivisiin toimintoihin 381:lla 5–12-vuotiaalla yhdysvaltalaisella lapsella. Osatutkimuksessa III tutkittiin tarkemmin yhtä neurokognitiivista toimintoa, kykyä tunnistaa tunteita, 370:llä 3–6-vuotiaalla suomalaisella lapsella. Osatutkimuksessa selvitettiin toiminnon kehityskäyrää sekä sen yhteyttä muihin neurokognitiivisiin toimintoihin. Kaikissa osatutkimuksissa käytettiin kattavan ja kansainvälisen lastenneuropsykologisen tutkimusmenetelmän (NEPSY-II) standardointiaineistoa.

Neurokognitiiviset toiminnot olivat yhteydessä kaikkiin tutkittuihin muuttujiin. Osatutkimuksessa I kulttuurilliset erot tulivat esiin useimmissa neurokognitiivisissa toiminnoissa, varsinkin pienimmillä lapsilla, ja kehityskäyrissä oli eroja. Osatutkimuksessa II mediankäyttö oli myös yhteydessä neurokognitiiviseen suoriutumiseen yhdysvaltalaisilla lapsilla. Tv:n katselulla oli negatiivinen yhteys neurokognitioon, kun taas tietokoneen käyttämisellä oli positiivinen yhteys joihinkin neurokognitiivisiin toimintoihin. Lukemisella oli positiivinen yhteys joihinkin toimintoihin nuorempien lasten kohdalla sekä äidin koulutuksen ollessa matalampi. Osatutkimuksessa III tunteiden tunnistamiskyvyllä oli ominainen kehityskäyrä päiväkoti-ikäisillä suomalaisilla lapsilla, ja se oli yhteydessä muihin neurokognitiivisiin toimintoihin, erityisesti kieleen.

Kokonaisuutena tulosten mukaan neurokognitiiviset toiminnot kehittyvät suhteessa lapsen ympäristöön ja taustaan. Kulttuuri- ja mediakäytön erot voivat iän ja vanhempien koulutuserojen lisäksi osittain selittää lastenneuropsykologisissa tutkimuksissa esiintyvää neurokognitiivista vaihtelua. Lisäksi muiden neurokognitiivisten toimintojen vaikeudet voivat osittain

selittää tunteiden tunnistamiskyvyssä ilmeneviä vaikeuksia. Näillä löydöksillä on vaikutusta perheille sekä monikulttuurisiin tutkimuksiin eri maissa. Vaikutukset liittyvät myös englannin- ja ruotsinkielisten lasten Suomessa tutkimisen suosituksiin. Kokonaisuudessa, väitöskirjan osatutkimukset tuovat uutta tietoa kulttuurin, median ja sosiaalisten toimintojen yhteydestä neurokognitioon.

SAMMANFATTNING

Neurokognitiva funktioner hos barn, exempelvis uppmärksamhet/exekutiva funktioner, språkliga funktioner, minnes- och inlärningsfunktioner, sensomotoriska funktioner, social perception och visuospatiala funktioner utvecklas i takt med åldern. Detta sker som en följd av att hjärnan utvecklas, men även i nära samband med barnets bakgrund och omgivning. Bakgrunds- och omgivningsfaktorer kan därmed förklara variation i neurokognitiv prestation. För att förstå neurokognitiva svårigheter behövs information om typisk neurokognitiv utveckling. Målsättningen med avhandlingen var att utforska relationen mellan bakgrundsvariabler och neurokognitiv prestation hos ålderstypiska barn.

Avhandlingen består av tre empiriska artiklar som utforskar sambandet mellan bakgrunds-, omgivnings- och neurokognitiva variabler i ett stort sampel bestående av barn i åldern 3–15 år från tre länder. I delstudie I jämfördes den tvärsnittliga utvecklingen av neurokognitiva funktioner hos 2745 barn i åldern 3–15 år från Finland, Italien och USA. Studien undersökte därmed sambandet mellan kultur och neurokognition. Delstudie II utforskade sambandet mellan användningen av media, d.v.s. tidsanvändningen för tv-tittande, datoranvändning eller läsning, och neurokognitiva funktioner hos 381 barn i åldern 5–12 år, från USA. Delstudie III undersökte en specifik neurokognitiv funktion, förmågan att känna igen emotionsuttryck, hos 370 finländska barn i åldern 3–6 år. I delstudien utforskades funktionens utvecklingsmässiga sekvens, samt sambandet mellan emotionsigenkänning och andra neurokognitiva funktioner. I alla tre studier användes standardiseringsdata från den mångsidiga och internationella undersökningsmetoden NEPSY-II.

Resultaten visade att neurokognitiva funktioner hade ett samband med alla studerade variabler. I delstudie I framkom kulturella skillnader i de flesta neurokognitiva funktioner, speciellt hos yngre barn och med något olika utvecklingsförlopp i de tre länderna. I delstudie II hade användningen av media också ett signifikant samband med neurokognitiv prestation. Tv-tittande hade ett negativt samband med neurokognition, medan datoranvändning hade ett positivt samband med vissa neurokognitiva funktioner. Läsning hade ett positivt samband med vissa funktioner hos yngre barn och då mammans utbildningsnivå var lägre. I delstudie III uppvisade emotionsigenkänning ett specifikt utvecklingsförlopp hos barn under skoläldern och hade ett samband med andra funktioner, speciellt språk.

Sammanlagt visar resultaten att neurokognitiva funktioner utvecklas i samverkan med barnets omgivning och bakgrund. Skillnader i kultur och medieanvändning kan, som tillägg till ålder och föräldrarnas utbildningsnivå, förklara en del av den variation i neurokognitiv prestation som framkommer i kliniska utredningar av barn. Därtill kan svårigheter i neurokognitiva

funktioner delvis förklara svårigheter i emotionsigenkänning. De föreliggande resultaten har implikationer för familjer och multikulturella utredningar av barn i olika länder. Utgående från resultaten kan också vissa riktlinjer för utredning av engelsk- och svensktalande barn i Finland anges. Sammantaget tillför de tre studierna ny information till de neuropsykologiska forskningsfälten som omfattar studier i kultur, media och sociala funktioner.

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LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following publications:

I Rosenqvist, J., Lahti-Nuuttila, P., Urgesi, C., Holdnack, J., Kemp, S. L., & Laasonen, M. (2017). Neurocognitive functions in 3-to 15-year-old children: An international comparison. *Journal of the International Neuropsychological Society*, 23:4, 367-380, doi: 10.1017/S1355617716001193

II Rosenqvist, J., Lahti-Nuuttila, P., Holdnack, J., Kemp, S.L., Laasonen, M. (2016). Relationship of TV watching, computer use, and reading to children's neurocognitive functions, *Journal of Applied Developmental Psychology*, 46, 11-21, doi:10.1016/j.appdev.2016.04.006

III Rosenqvist, J., Lahti-Nuuttila, P., Laasonen, M., & Korkman, M. (2014). Preschoolers' recognition of emotional expressions: Relationships with other neurocognitive capacities, *Child Neuropsychology*, 20:3, 281-302, doi:10.1080/09297049.2013.778235

The publications are referred to in the text by their roman numerals.

ABBREVIATIONS

η_p^2	partial eta squared, effect size
AEF	Attention and Executive Functioning, a NEPSY-II domain
ANOVA	analysis of variance
AR	Affect Recognition, a NEPSY-II subtest
ASD	autism spectrum disorder
AW	Arrows, a NEPSY-II subtest
BC	Block Construction, a NEPSY-II subtest
CI	Comprehension of Instructions, a NEPSY-II subtest
d	standardized mean difference, effect size
DC	Design Copying, a NEPSY-II subtest
GLM	General Linear Model
GP	Geometric Puzzles, a NEPSY-II subtest
hr	hour
L	Language, a NEPSY-II domain
MANOVA	multivariate analysis of variance
MFD	Memory for Faces Delayed, a NEPSY-II subtest
MFI	Memory for Faces Immediate, a NEPSY-II subtest
ML	Memory and Learning, a NEPSY-II domain
na	not applicable
NEPS	Neuropsychological assessment of children
NEPSY	A developmental neuropsychological assessment
NEPSY-II	A developmental neuropsychological assessment, second edition
ns	not significant
PH	Phonological Processing, a NEPSY-II subtest
SP	Social Perception, a NEPSY-II domain
TV	television
TM	Theory of Mind, a NEPSY-II subtest
U.S.	United States
VP	Visuospatial Processing, a NEPSY-II domain
WISC-III	Wechsler Intelligence Scale for Children, third edition

1 INTRODUCTION

During the past decades, researchers and clinicians have shown an interest in children's neurocognitive functions[1], such as, attention/executive functions, language, memory/learning, social perception, sensorimotor functions, and visuospatial processing, not the least because of their relationship with children's academic performance (e.g., Allan, Hume, Allan, Farrington, & Lonigan, 2014; Ardila & Rosselli, 1994; Grissmer, Grimm, Aiyer, Murrah, & Steele, 2010; Landerl et al., 2012; Moll et al., 2014). Developmental trajectories of neurocognitive functions have been presented for different tasks (e.g., Korkman, Kemp, & Kirk, 2001; Korkman, Lahti-Nuuttila, Laasonen, Kemp, & Holdnack, 2013; Rosselli, Ardila, Navarrete, & Matute, 2010; Waber et al., 2007). Such development of neurocognitive performance is thought to follow brain maturation (e.g., Casey, Giedd, & Thomas, 2000; Casey, Tottenham, Liston, & Durston, 2005; Fuster, 2002). However, neurocognitive performance also reflects influences of the background of the child. For instance, socioeconomic factors and parental education level are related to performance on a variety of neurocognitive tasks (e.g., Hackman & Farah, 2009; Letts, Edwards, Sinka, Schaefer, & Gibbons, 2013; McLoyd, 1998; Sarsour et al., 2011). There are indications of other cognitive characteristics and environmental factors, such as cultures and different aspects of the home environment, and other neurocognitive functions relating to neurocognitive performance (e.g., Anders et al., 2012; Byrd, Arentoft, Scheiner, Westerveld, & Baron, 2008; Devine & Hughes, 2014; Downer & Pianta, 2006; Korkman et al., 2001; McLoyd, 1998; Olson & Jacobson, 2015; Pinto, Pessanha, & Aguiar, 2013; Sarsour et al., 2011; Shahaeian, Henry, Razmjoee, Teymoori, & Wang, 2015; Tong, Baghurst, Vimpani, & McMichael, 2007). Understanding neurocognitive performance in typically developing children is a prerequisite to understanding dysfunctional brain–behavior relationships. Thus, elucidating the relationships between background and environmental factors and neurocognition may have implications not only for understanding typical neurocognitive development but also for assessment and rehabilitation of atypical functioning.

[1] In the pediatric neuropsychological literature, "cognitive" and "neurocognitive" have often been used interchangeably. For the purpose of the present study, the tradition among research concerning NEPSY-II and it's predecessors, in which "neurocognitive" generally has been used, has been followed (e.g., Korkman, 1999; Korkman et al., 2001, Korkman et al., 2007b, 2008b; Korkman et al., 2013).

1.1 ASSESSING NEUROCOGNITION

When a child experiences difficulties in school or at home, he or she may be referred for neuropsychological assessments. In addition to traditional intelligence measures, tasks focusing on more specific aspects of neurocognition are used to assess the child's strengths and difficulties. One such tool, the NEPSY-II, a Developmental Neuropsychological Assessment, second edition (Korkman, Kirk, & Kemp, 2007a, 2007b, 2008a, 2008b, 2011a; Urgesi, Campanella, & Fabbro, 2011), is a comprehensive clinical neuropsychological assessment that is widely used by psychologists and neuropsychologists in several countries. The first version of the assessment, NEPS, was developed in Finland in 1980 by Marit Korkman (Korkman et al., 2008b). Since then, several new versions, with expansions and modifications of the tasks and age range, have been published in several countries. The test was first made available in English by the publication of NEPSY (published in 1998 in the United States and 1997 in Finland [Korkman et al., 2008b]). The most recent version, the NEPSY-II, has been published in the United States (Korkman, et al., 2007a, 2007b), Finland (Korkman, et al., 2008a, 2008b), and Italy (Korkman, et al., 2011; Urgesi, et al., 2011) as well as in other European countries, including Sweden (Korkman, Kirk, & Kemp, 2011b).

NEPSY-II has frequently been used in studies. Such studies have, for example, reported differences in neurocognitive performance between clinical groups of children with anorexia nervosa, very or extremely low birth weight, autism spectrum disorder (ASD), or fetal alcohol spectrum disorder, as well as in children who have had an organ transplant, as compared to a control group of typically developing children, (e.g., Munck et al., 2012; Rasmussen et al., 2013), a control group of matched normative data (e.g., Barron-Linnankoski et al., 2015; Calderoni et al., 2013; Haavisto et al., 2011; Haavisto, Korkman, Holmberg, Jalanko, & Qvist, 2012; Narzisi, Muratori, Calderoni, Fabbro, & Urgesi, 2012; Reinvall, Voutilainen, Kujala, & Korkman, 2013), or the norms (Koivisto et al., 2015). Performance by comparing bilingual to monolingual children has also been investigated (Karlsson et al., 2015). Other studies, in turn, have directly investigated the standardization data (e.g., Brooks, Sherman, & Iverson, 2010; Kinnunen, Korkman, Laasonen, & Lahti-Nuuttila, 2013; Klenberg, Närhi, Korkman, & Hokkanen, 2015; Korkman et al., 2013), outlaying the developmental trajectories and typical performance on the tasks. Further, reviews of NEPSY-II have generally found the reliability and validity of the subtests in the assessment to be fairly good (Brooks, Sherman, & Strauss, 2010; Davis & Matthews, 2010). Thus, the clinical utility of the assessment has been previously investigated rather extensively.

1.2 VARIATION IN NEUROCOGNITIVE PERFORMANCE

Children experiencing cognitive or behavioral deficits or disorders often show difficulties on some neurocognitive tasks (e.g., Barron-Linnankoski et al., 2015; Koivisto et al., 2015; Reinvall et al., 2013). In general, small differences among scores on cognitive tests are not indicative of significant difficulties (Wechsler, 2010). In fact, it is common for healthy children to perform somewhat below the expected age level on at least a few neuropsychological tasks (Brooks, Iverson, Sherman, & Holdnack, 2009; Brooks, Sherman, & Iverson, 2010), and similar findings have been reported for adults (e.g., Binder, Iverson, & Brooks, 2009; Brooks, Iverson, & White, 2009). This is a typical finding when carrying out psychological tests, and different factors, such as the overall cognitive performance or parental education level, may partly explain such variation (Brooks, Iverson, Sherman, et al., 2009; Brooks, Sherman, & Iverson, 2010).

In fact, performance on neurocognitive tasks has fairly consistently been shown to vary with a child's age, with scores improving as the child grows (e.g., Korkman et al., 2001; Korkman et al., 2013; Rosselli et al., 2010; Waber et al., 2007), or with other background variables, such as socioeconomic factors (Hackman & Farah, 2009; Letts et al., 2013; McLoyd, 1998; Sarsour et al., 2011). Thus, other cognitive characteristics and environmental factors may explain some of the variance observed on neurocognitive task performance. Factors of interest are cultures, media habits in the home, age-related changes, and other neurocognitive functions. The present thesis investigates the relationship between such factors and performance on NEPSY-II. In the following sections, these variables are discussed in more detail.

1.2.1 AGE

As children grow, their performance on neurocognitive tasks naturally improves. It has been shown for different neurocognitive tasks and in different languages that performance develops steeply until age 9 or 10, whereas the enhancement in neurocognitive task performance is slower during preadolescence and adolescence (e.g., Korkman et al., 2001; Korkman et al., 2013; Rosselli et al., 2010; Waber et al., 2007). Hence, throughout the present study, we expected age to be significantly related to neurocognitive performance. However, age-related changes in task performances may also relate to the environment and background of the child. Thus, it is possible that there might be differences in neurocognitive performance among different countries for different age groups, in other words, that the developmental trajectories of task performances may differ among different cultural groups.

1.2.2 CULTURE

Cultural/cross-cultural neuropsychology is a fairly new but growing research field, as seen by the growing number of publications of cross-cultural neuropsychology handbooks (Ferraro, 2016; Fletcher-Janzen, Strickland, & Reynolds, 2000; Rhodes, Ochoa, & Ortiz, 2005; Uzzell, Pontón, & Ardila, 2007), journal special issues (Grote, 2016; Manly, 2008a; Quintana et al., 2006), and webinars (Castro & Judd, 2015; Salinas & Vegas, 2016). "Culture" is a broad concept used in many different lines of research. Within the field of psychology, "culture" can be used to indicate, for instance, behaviors, traditions, religion, and economics among a group, and such aspects may be shared and transferred across generations (see Matsumoto & Juang, [2013] for a review, more examples and a discussion). Further, within neuropsychology, the concept of culture has been used to indicate, for example, significant task performance differences among various cultural groups, and questions regarding the impact of culture has stimulated various theoretical and practical discussions (see, for instance, Ferraro, 2016; Uzzell, et al., 2007). For the purpose of the present study, "cultural differences" is used to indicate an international comparison among countries.

Previous cross-cultural neuropsychological research has focused on, for instance, ethical and norm-related issues regarding cross-cultural neuropsychological assessments (e.g., Brickman, Cabo, & Manly, 2006; Manly, 2005; Manly, 2008b; Rivera Mindt, Byrd, Saez, & Manly, 2010), translations and use of assessments among cultures (A. S. Chan, Shum, & Cheung, 2003; Fasfous et al., 2015; Koch, Eksteen, & de Witt, 2015; Konstantopoulos, Vogazianos, Thodi, & Nikopoulou-Smyrni, 2015; Rivera Mindt et al., 2010; Semrud-Clikeman et al., 2016), different neuropsychological practices and cross-cultural education of neuropsychologists in different countries (Elbulok-Charcape, Rabin, Spadaccini, & Barr, 2014; Grote, 2016), or differences in test performance between cultural or ethnic groups (e.g., Gurven et al., 2017; Kisser, Wendell, Spencer, & Waldstein, 2012; Low et al., 2012; Manly, 2005; Rosselli et al., 2010; Zaroff, D'Amato, & Bender, 2014). Common to these previous studies is that the need for culturally conscious neuropsychological studies and practices has become clear (see, Rivera Mindt et al., 2010).

In adults, cross-cultural or ethnic differences in performance have fairly consistently been shown on different neurocognitive tasks (e.g., Brickman et al., 2006; Fernandez & Marcopulos, 2008; Kisser et al., 2012; Manly et al., 1998). Several previous studies have focused on performance differences among different ethnic groups in the United States (e.g., Manly et al., 1998; Boone, Victor, Wen, Razani, & Pontón, 2007; for summaries, see also Brickman et al., 2006; Manly, 2008b), but recent research has also focused on, for instance, neurocognitive profiles of refugees (Veliu & Leathem, 2016) or occurrence of diagnostic errors when assessing other cultural groups with North American tests (Daugherty, Puente, Fasfous, Hidalgo-Ruzzante, & Pérez-Garcia, 2016). Based on previous studies, we know that neither verbal nor visual tasks are culturally universal (Rosselli & Ardila, 2003) and that not only test results but also the assessment situation is influenced by culture (Ardila, 2005). However, even if cultural neurocognitive differences in adults have been shown, such previous findings have been ascribed to different factors, such as socioeconomic differences, differences in experience and understanding of assessment situations, quantity and quality of education, or to factors in the history of the cultural group at hand (e.g., Brickman et al., 2006; Ojeda, Aretouli, Peña, & Schretlen, 2014; Olson & Jacobson, 2015).

Regarding children, cross-cultural neurocognitive studies for most cognitive areas are still few. Previous studies have reported performance differences in non-Western children on Western-developed tasks (e.g., Rosselli & Ardila, 2003; Zaroff et al., 2014), and some, echoing studies with adults, have reported performance differences among different U.S. ethnic groups (e.g., Llorente, Turcich, & Lawrence, 2004; Pungello, Iruka, Dotterer, Mills-Koonce, & Reznick, 2009; Restrepo et al., 2006). Currently, the research field also discusses assessments of refugee children (Fraine & McDade, 2009; Kaplan, Stolk, Valibhoy, Tucker, & Baker, 2016).

In regards to more specific neurocognitive functions, there have been reports of some performance differences on, for example, tasks of attention/executive functions between Russian and Romanian children, between Zambian children and the U.S. normative data, and between Egyptian and Finnish children with ASD (Cheie, Veraksa, Zinchenko, Gorovaya, & Visu-Petra, 2015; Elsheikh et al., 2016; Mulenga, Ahonen, & Aro, 2001). Concerning neurocognitive areas included in the thesis, some differences have also been reported in visual and visuospatial functions (for a review, see Rosselli & Ardila, 2003). For instance, U.S. 3-year-olds outperformed their Japanese counterparts on tasks of object recognition (Kuwabara & Smith, 2016). In visual perception, children from Hong Kong outperformed Australian children, and Israeli children outperformed Palestinian children (Josman, Abdallah, & Engel-Yeger, 2006; Lai & Leung, 2012). On the Design Copying subtest from the NEPSY, Zambian children performed better than the U.S. normative group, and in Great Britain, bilingual children performed better than monolinguals (Garratt & Kelly, 2008; Mulenga et al., 2001).

On language tasks, the cross-cultural studies have yielded contradictory results. Cultural differences have been reported for the NEPSY subtests Body Part Naming (Korkman et al., 2012; Westman, Korkman, Mickos, & Byring, 2008), Speeded Naming, and Comprehension of Instructions (Garratt & Kelly, 2008), with monolinguals outperforming bilinguals. However, no significant differences have also been reported for the subtests Speeded Naming, Comprehension of Instructions (Korkman et al., 2012; Westman et al., 2008), and Phonological Processing (Garratt and Kelly, 2008; Westman et al., 2008). A more recent study with typically developing monolingual and bilingual Finnish children found no differences on the NEPSY-II language tasks Comprehension of Instructions, Phonological Processing, Speeded Naming, and Word Generation (Karlsson et al., 2015). Some language differences have also been reported among ethnic groups in the United States (Llorente, et al., 2004; Restrepo et al., 2006), whereas other studies have not found significant differences (Qi, Kaiser, Milan, & Hancock, 2006). Cross-country comparisons have reported Zambian children performing poorer than U.S. norms on the NEPSY language domain, and Finnish children with ASD scoring higher than Egyptian children with ASD on the NEPSY language subtests Comprehension of Instructions, Comprehension of Sentence Structure, and Verbal Fluency (Elsheikh et al., 2016; Mulenga et al., 2001).

Previous pediatric[2] research indicates no cultural differences on face memory tasks in 6–10 year olds (Elsheikh et al., 2016; Garratt & Kelly, 2008). Children and adults better recognize faces from their own cultural group (e.g., De Heering, De Liedekerke, Deboni, & Rossion, 2010; Fioravanti-Bastos, Filgueiras, & Landeira-Fernandez, 2014; for a summary, see Wan et al., 2017). However, the development of face memory remains to be explored in larger age spans, including both younger and older children, and between Western countries.

In contrast to most other neurocognitive functions, social perception has gained much previous interest. The universality of the ability to recognize emotional expressions has intrigued researchers for centuries (for summaries of the early studies, see Scherer, Clark-Polner, & Mortillaro, 2011; Steele, Steele, & Croft, 2008; van Hemert, Poortinga, & van de Vijver, 2007). It seems that the emotion recognition ability is fairly similar across cultures (Scherer et al., 2011), even though this view has been challenged with reports of significant differences in emotion recognition in different cultural and language groups (Nelson & Russell, 2013). There is a tendency to more accurately recognize emotions expressed by someone of one's own cultural group (Elfenbein & Ambady, 2002; Elfenbein & Ambady, 2003), especially for Western participants (Scherer et al., 2011). Previous pediatric studies have used widely different methodologies when assessing emotion recognition, such as situation discrimination or labeling tasks (e.g., Markham & Wang, 1996; Molina, Bulgarelli, Henning, & Aschersleben, 2014). Non-verbally assessed—that is, when the methodology is comparable to the task included in NEPSY-II—cross-cultural comparisons of the development of this ability have knowingly not yet been conducted.

The proposed universality of the theory of mind ability has also been extensively studied, often using false belief tasks with a pass-fail scoring, across several countries and cultures (for summaries of previous studies, see for instance, Mayer & Träuble, 2013; Wang, Devine, Wong, & Hughes, 2016). While there is evidence that children from different cultures gain this ability (e.g., Callaghan et al., 2005; Oh & Lewis, 2008; Sabbagh, Xu, Carlson, Moses, & Lee, 2006; Shahaeian, Peterson, Slaughter, & Wellman, 2011; Shahaeian, Nielsen, Peterson, Aboutalebi, & Slaughter, 2014), the rate of development of performance on different theory of mind tasks has been observed to differ when comparing children from Hong Kong to children from mainland China and North America, as well as when comparing Iranian children to Australian children (e.g., Liu,

[2] For the purpose of the present thesis, and in accordance with the research field, the terms "pediatric" and "child" or "adolescent" will be interchangeably used.

Wellman, Tardif, & Sabbagh, 2008; Shahaeian et al., 2011; Shahaeian, Nielsen, Peterson, & Slaughter, 2014; Shahaeian, Nielsen, Peterson, Aboutalebi et al., 2014). Some studies have reported performance differences on theory of mind tasks among different cultural groups, such as Korean children outperforming U.S. and British children and British children outperforming Italian and Japanese children (e.g., Ahn & Miller, 2012; Hughes et al., 2014; Lecce & Hughes, 2010; Naito & Koyama, 2006). Such differences have often been attributed to a variety of factors, such as differences in background, home environment, education, or parenting, as well as to other cultural or assessment-related differences between the samples, or to a combination of several factors (Ahn & Miller, 2012; Hughes et al., 2014; Hughes, Devine, & Wang, 2017; Lecce & Hughes, 2010; Liu et al., 2008; Mayer & Träuble, 2013; Mizokawa & Lecce, 2016; Naito & Koyama, 2006; Shahaeian et al., 2011; Shahaeian, Nielsen, Peterson, & Slaughter, 2014; Wang et al., 2016).

Due to the young cross-cultural pediatric neuropsychology field focusing on somewhat different aspects of the neurocognitive abilities and using differing measures in various cultural groups, drawing strong conclusions from the previous studies has complications. Most previous studies have focused on fairly narrow age ranges, a limitation that was pointed out almost 10 years ago (Byrd et al., 2008). Still, based on previous studies, in the present investigation, some cultural differences can be expected and some possible explanatory factors for these differences can be applied from previous reports (e.g., Brickman et al., 2006; Ojeda et al., 2014; Olson & Jacobson, 2015).

1.2.3 MEDIA USE

In addition to cultures, socioeconomic status, and parental education level (Letts et al., 2013; McLoyd, 1998; Sarsour et al., 2011), different aspects of a child's home environment have been shown to be related to academic achievement and performance on different cognitive tasks (e.g., Anders et al., 2012; Burger, 2010; Davis-Kean, 2005; Downer & Pianta, 2006; Pinto et al., 2013; Tong et al., 2007). Since the invention of the television (TV), and with the rapid development of different media devices and use during the past decades, the effects of media use on children's development, functioning, and general wellbeing have gained much interest (e.g., Brown & Bobkowski, 2011; N. Cain & Gradisar, 2010; Hale & Guan, 2015; Nikkelen, Valkenburg, Huizinga, & Bushman, 2014; Rosen et al., 2014; Schmidt & Vandewater, 2008; Zhang, Tillman, & An, 2017).

Media use has been studied from many angles. Recently, computer games aiming at training cognitive functions have been discussed and investigated with the hope of using computer games in clinical neuropsychological rehabilitation and training (for a review, see Green & Seitz, 2015). As a part of this discussion, performance on NEPSY-II subtests has been shown to significantly correlate with performance on specific computer games, thus indicating that certain tasks and games utilize the same cognitive skills (Martinovic, Burgess, Pomerleau, & Marin, 2015). Specific neural systems relating to media use have been proposed (Meshi, Tamir, & Heekeren, 2015). Further, recent research has reported some negative relationships between cognition and media multitasking (e.g., M. S. Cain, Leonard, Gabrieli, & Finn, 2016; Cardoso-Leite et al., 2016; Moisala et al., 2016; Ophir, Nass, & Wagner, 2009). These lines of research will likely bring forward important information for clinical use and neuropsychological rehabilitation. Still, it is important to consider separately the relationships between neurocognitive performance and time spent on different forms of media use, as this can form the basis of specific recommendations for clinicians and families to address unhealthy media use habits in children.

However, comparing previous studies of TV watching, computer use, and reading is complicated due to several factors. Previous studies have focused on different age groups, ranging from infants to adults (e.g., Mol & Bus, 2011; Schmidt & Vandewater, 2008; Swing, Gentile, Anderson, & Walsh, 2010). Different measures have been used regarding both the assessment of cognitive functions and media variables. Some studies have utilized an experimental design (e.g., Dworak, Schierl, Bruns, & Struder, 2007), while others have investigated media use with a correlational approach using, for example, self- or parent-rated questionnaires (e.g., Malhi, Bharti, & Sidhu, 2016; O'Connor et al., 2016; Swing et al., 2010). With children spending an increasing amount of time on media (Rideout, Foehr, & Roberts, 2010), attempts at further investigating the relationship between time spent using different media and performance on neurocognitive tasks is of interest to families, clinicians, and researchers.

Previous studies investigating TV watching in relation to educational achievement and neurocognitive functions have yielded inconsistent findings. Most studies have indicated negative or no significant effects of TV watching on performance, mostly in adolescence (e.g., Kang & Park, 2016; Malhi et al., 2016; O'Connor et al., 2016; Razel, 2001; Sharif, Wills, & Sargent, 2010; Shashi Kumar et al., 2013) but also in young children (Schmidt, Rich, Rifas-Shiman, Oken, & Taveras, 2009). Some exceptions have been reported (see Singh & Gaurav [2013], also for a comprehensive summary of the conflicting findings of the effects of TV watching).

Similarly, studies have reported inconsistent findings when it comes to relationships with more specific neurocognitive abilities. Some have reported negative relationships between TV watching and attentional functions, positive relationships between TV watching and ADHD-like behavior across childhood (e.g., Acevedo-Polakovich, Lorch, Milich, & Ashby, 2006; Levine & Waite, 2000; Lillard & Peterson, 2011; Nikkelen et al., 2014; Swing et al., 2010; Séguin & Klimek, 2016), and negative relationships between TV watching and language in young children (Chonchaiya & Pruksananonda, 2008). The theory of mind ability had some negative relationships with TV exposure in preschool-aged children (Nathanson, Sharp, Aladé, Rasmussen, & Christy, 2013). Other studies have found positive relationships between TV watching and language in infants and young children (e.g., Linebarger & Walker, 2005), and still others found no significant relationships between TV watching and attention and inhibition in older childhood (Verburgh, Scherder, Van Lange, & Oosterlaan, 2016) or memory in older children and adolescents (Dworak et al., 2007; Verburgh et al., 2016). Further, some previous findings concerning the relationship among attentional, executive functioning, working memory, or language performance and TV watching have been attributed to different confounding or socio-demographic factors or methodological differences (Blankson, O'Brien, Leerkes, Calkins, & Marcovitch, 2015; Ferguson, Coulson, & Barnett, 2011; Foster & Watkins, 2010; O'Connor et al., 2016).

In adults, computer use studies have often compared the performance of computer/video game players on different tasks to non-players or investigated the immediate training effects of video game playing on performance on different cognitive tasks (e.g., Green & Bavelier, 2012; Green & Seitz, 2015; Spence & Feng, 2010), reporting indications of positive findings. The methodologies used in adult studies specifically relating action video game playing to cognition have, however, been questioned (Boot, Blakely, & Simons, 2011; van Ravenzwaaij, Boekel, Forstmann, Ratcliff, & Wagenmakers, 2014). Studies investigating children's computer use have focused on different aspects of the use of this medium in relation to different aspects of academic or neurocognitive performance (for a summary, see, Tran & Subrahmanyam, 2013). Previous research has reported positive relationships among different kinds of computer use, mainly computer game playing, and educational and cognitive achievement in school-aged children or adolescents (Borzekowski & Robinson, 2005; Fiorini, 2010; Jackson et al., 2006; Malhi et al., 2016), attention and executive functions in children and adults (Dye, Green, & Bavelier, 2009; for a review, see Schmidt & Vandewater, 2008), and some visuospatial skills in children (for a review, see Schmidt & Vandewater, 2008). However, negative relationships among general computer use or gaming and attention and inhibition skills in school-aged children and adolescents (P. A. Chan & Rabinowitz, 2006; Swing et al., 2010; Verburgh et al., 2016) and verbal memory in adolescents (Dworak et al., 2007) have also been reported. Some studies have found no relationship between video game playing and achievement in middle childhood (Skoric, Teo, & Neo, 2009), as well as with attention (Ferguson et al., 2011) or visuospatial functions (Ferguson, Garza, Jerabeck, Ramos, & Galindo, 2013) in older childhood and adolescence. In all, studies investigating children's time spent on a computer in relation to neurocognitive functioning are still sparse, and studies investigating this relationship comprehensively spanning several age groups and cognitive domains are still missing.

Compared to TV watching and computer use, few studies have investigated time spent reading in relation to neurocognitive performance. Previous research has shown unanimous positive relationships between reading and academic achievement or language performance (Echols, West, Stanovich, & Zehr, 1996; Evans, Kelley, & Sikora, 2014; Mol & Bus, 2011; Rowe, 1991; Whitehurst & Lonigan, 1998). An indication of a positive relationship between reading and attentional functions has been presented (Rowe, 1991). More specifically, a meta-study by Mol and Bus (2011) indicated a positive relationship among exposure to reading materials and reading/spelling skills, academic achievement, language performance, and intelligence across childhood, from kindergarten to graduate students. However, knowledge regarding the relationship between reading and comprehensively assessed neurocognitive functions in a broad age range are still missing.

In general, media use in relation to a child's neurocognitive performance has gained much research interest during the past several decades. Nevertheless, studies investigating more specific relationships between watching TV, using the computer, or reading and comprehensively assessed neurocognitive functions for a broad age range are still missing.

1.2.4 EMOTION RECOGNITION

Of the neurocognitive tasks included in NEPSY-II, previous studies have fairly extensively investigated performance on attentional, language, memory, and visuospatial tasks (e.g., Kinnunen et al., 2013; Klenberg, Korkman, & Lahti-Nuuttila, 2001; Klenberg et al., 2015; Korkman et al., 2001; Korkman et al., 2013). As mentioned, a previous comprehensive study reported developmental trajectories of 5–16 year olds for several of the subtests included in NEPSY-II (Korkman et al., 2013). However, specific information on the developmental trajectory of one neurocognitive ability—the ability to recognize expressions of emotions—is limited. This subtest was a new addition to NEPSY-II as compared to previous versions of the assessment (Korkman, et al., 2007b). Hence, it has been less studied than most other tasks included in the assessment, and variables relating to variation in performance on this task have not been explored.

The emotion recognition ability is important, as shown by recent studies: This ability has been reported to be impaired, at least to some extent, in children or adolescents with ASD, schizophrenia, externalizing behaviors, Down syndrome, and intellectual disabilities, (e.g., Cebula, Wishart, Willis, & Pitcairn, 2017; Chronaki et al., 2015; Corcoran et al., 2015; Sivaratnam, Newman, Tonge, & Rinehart, 2015). Moreover, better emotion recognition, as assessed by NEPSY-II, has been shown to be related to better moral reasoning skills (Vera-Estay, Seni, Champagne, & Beauchamp, 2016). Similar to other neurocognitive functions, emotion recognition also develops with age (Bruce et al., 2000; Herba, Landau, Russell, Ecker, & Phillips, 2006; Karayanidis, Kelly, Chapman, Mayes, & Johnston, 2009; Markham & Adams, 1992; Smith & Walden, 1998; Vicari, Snitzer Reilly, Pasqualetti, Vizzotto, & Caltagirone, 2000; Walden & Field, 1990). However, even though the developmental trajectory of this ability has been presented for 5–16 year olds in a previous study by Korkman and colleagues (2013), it has not been explored more thoroughly in young preschool-aged children.

Emotion recognition development in the preschool-age period is especially interesting, because this is a time when children often form social relationships outside of the immediate family (see Gagnon & Nagle, 2004), and it has been shown that the social development during this time has effects on social behavior and educational performance long into later childhood (Izard et al., 2001; Trentacosta & Izard, 2007; Walden & Field, 1990; see also Gagnon & Nagle, 2004). While the ability to non-verbally match expressions seems to be fairly developed in school-aged children (De Sonneville et al., 2002), emotion labeling has been shown to develop well into childhood (Vicari et al., 2000; Widen & Russell, 2003, 2010). In addition, we now know that preschoolers are better at recognizing facial expressions of emotions than vocal emotional expressions (Chronaki et al., 2015). Detailed information about preschooler's emotion matching performances are, thus, important.

Further, understanding deficits and typical development of functions requires that factors possibly relating to the functions are investigated. There are previous indications of cognitive functions relating, mainly positively, to some emotion recognition tasks across the lifespan (e.g., Buitelaar, van der Wees, Swaab-Barneveld, & van der Gaag, 1999; Mathersul et al., 2009; Walden & Field, 1990). These findings have been contradicted by Montirosso and colleagues (2010), who found no relationship between emotion processing and general cognition. Regarding more specific neurocognitive abilities, there are some indications of emotion recognition, as assessed with different tasks and in different age groups, relating to attention/executive functioning (Mathersul et al., 2009; Rosenberg-Kima & Sadeh, 2010; Shin, Lee, Kim, Park, & Lim, 2008), language (Ford & Milosky, 2003; Smith & Walden, 1998), memory (Buitelaar et al., 1999; Mathersul et al., 2009), sensorimotor function (Mathersul et al., 2009), visuospatial processing (Herba et al., 2006; Székely et al., 2011), and theory of mind (Buitelaar & van der Wees, 1997; Dyck, Piek, Hay, Smith, & Hallmayer, 2006; Mier et al., 2010), mostly positively. Still, some non-significant findings have also been reported between emotion recognition performance and language (Ford & Milosky, 2003; Herba et al., 2006; Herba et al., 2008; Hopyan-Misakyan, Gordon, Dennis, & Papsin, 2009; Spackman, Fujiki, Brinton, Nelson, & Allen, 2005).

In general, there seems to be some indication of relationships between emotion recognition and neurocognitive functions. However, previous studies have used different measures of emotion recognition and cognitive/neurocognitive functions and assessed different age groups. Therefore, an investigation of the relationship between emotion recognition and comprehensively assessed neurocognition in preschoolers is still needed.

2 AIMS OF THE STUDY

The present thesis explores variation neurocognitive performance in preschool- and school-aged children. Normative samples from Finland, Italy, and the United States of the child neuropsychological assessment NEPSY-II are utilized for this purpose. The aims of the three included studies are to explore cultural differences in performance on neurocognitive tasks (Study I), the relationship between media use and performance on neurocognitive tasks (Study II), and the development of one specific neurocognitive function—the emotion recognition ability—and the relationship between this function and other neurocognitive abilities (Study III).

More specifically, the aim of Study I was to compare performance on 10 subtests from the NEPSY-II among different age groups of 3- to 15-year-old Finnish, Italian, and U.S. children, thus cross-culturally exploring the cross-sectionally assessed development on neurocognitive tasks across childhood. The specific aim of Study II was to investigate how time spent watching TV, using the computer, or reading relates to performance on NEPSY-II domains in 5- to 12-year-old U.S. children, while controlling for age, sex, and maternal education level. The aim of Study III was to explore the cross-sectionally assessed developmental curve of performance on the non-verbal NEPSY-II emotion recognition task Affect Recognition and the relationship between performance on this task and other domains from the NEPSY-II.

3 METHODS

3.1 PARTICIPANTS AND PROCEDURES

The 3–15-year-old subjects were Finnish, Italian, and U.S. children who participated in the standardization of NEPSY-II in each country (Korkman, et al., 2007a, 2007b, 2008a, 2008b, 2011a; Urgesi, et al., 2011). The children were typically developing, that is, they had no neurological or developmental disorders, as reported by parents or teachers. They were assessed in their own language— Finnish, Italian, or English— by professionals or students, which were trained and supervised in assessment and scoring. The characteristics of the participants in the three studies are shown in Table 1.

The Finnish standardization was conducted in 2006 and 2007. Participants were 923 children—3–9, 11, 13, and 15 years old (M = 7.68, SD = 3.64)—randomly selected from the Finnish population register (Korkman, et al., 2008b) and invited by letters to the families. The children were assessed around their birthday (± 3 months). The standardization participants were divided among the capital area, university towns, and larger and smaller municipalities.

In the Italian standardization, conducted during 2007–2009, 800 children 3–16 years old (M = 8.33, SD = 3.60) were assessed throughout the year from birthday to birthday. The children were recruited from preschools, elementary schools, secondary schools, technical and vocational schools from different areas in Italy, and one Italian-speaking area in the south of Switzerland (Korkman, et al., 2011a). The whole grade was always assessed.

For the U.S. standardization, conducted in 2005 and 2006, 1,200 U.S. children (M = 8.67, SD = 3.73) 3–16 years old were assessed. The assessing psychologist or Pearson sampling staff recruited the children for the standardization. The children were assessed throughout the year. The October 2003 U.S. census data were applied when stratifying the groups on background variables (age, sex, ethnicity, parental education level, and geographic region) (Korkman, et al., 2007b). These background variables were not included in the present analyses. Consent was obtained from all participating families. The Committee for Research Ethics at Åbo Akademi University and the Scientific Institute Eugenio Medea provided ethical approval for the Finnish and Italian data, respectively. Ethical principles were also followed in the U.S. standardization (Korkman, et al., 2007b). For data collection in all countries, the Helsinki Declaration ethical principles were applied.

3.1.1 THE COUNTRY STUDY (STUDY I)

The participants in Study I were 2,745 Finnish, Italian, and U.S. children 3–15 years old (Finnish N = 821, Italian N =774, and U.S. N =1,150). To comprise similar age groups in all three countries, the assessed Italian and U.S. 16 year olds were not included in the analyses. In the Italian and U.S. data collections, children with reported difficulties were not included in the assessments. In the Finnish data, there were no children with diagnosed disorders, and children with parentally reported neurological or neuropsychological deficits were excluded from the study.

3.1.2 THE MEDIA STUDY (STUDY II)

The participants in Study II were 381 U.S. children 5–12 years old. For all 5–12 year olds in the standardization sample, parents were asked to complete an extensive home environment questionnaire. Included in Study II were all children with available home environment information (participation rate 51%). The home environment questionnaire was extensive, which might explain the high number of attrition. Further, excluded from the study were children with a reported native language other than English, or children with missing maternal education information.

3.1.3 THE EMOTION RECOGNITION STUDY (STUDY III)

The participants in Study III were 370 Finnish 3–6 year olds (2 years 10 months to 6 years 2 months). A child was included in the study if he or she did not have missing data on the Affect Recognition subtest. Excluded from the study were children with neurological or neuropsychological difficulties, as reported by parents.

3.2 NEUROPSYCHOLOGICAL ASSESSMENT

NEPSY-II is a comprehensive child assessment, which can be administered to 3–16 year olds. It consists of six domains: Attention and Executive Functioning, Language, Memory and Learning, Sensorimotor, Social Perception, and Visuospatial Processing, into which 29 (Finnish version) or 33 (Italian and U.S. versions) subtests are divided. Most subtests are present in all three country versions. However, some subtests were not included in all standardizations, and some had different rules and scoring procedures. A summary of all NEPSY-II subtests with similarities and differences among the three versions can be found in Table 2.

Most NEPSY-II subtests can be presented to all 3–16-year-old children, with the difficulty of the subtest increasing by each item. However, some subtests are given only to specific age groups, and for some subtests, the stimuli changes with

Table 1 *Descriptives (n) of the Data, Separately for the Three Studies.*

				Number of Children													
Age in Years				3	4	5	6	7	8	9	10	11	12	13	14	15	**Total**
Study I	*N*	Total		262	271	293	247	267	271	228	171	218	147	139	74	157	**2,745**
			FIN	101	97	107	98	83	70	68	-	67	-	62	-	68	**821**
			ITA	61	74	86	49	84	101	60	71	51	47	27	24	39	**774**
			U.S.	100	100	100	100	100	100	100	100	100	100	50	50	50	**1150**
	Sex	Girls	FIN	51	56	59	50	38	45	32	-	39	-	36	-	43	**449**
			ITA	29	38	48	22	37	51	34	34	22	22	15	9	26	**387**
			U.S.	50	50	50	50	50	50	50	50	50	50	25	25	25	**575**
		Boys	FIN	50	41	48	48	45	25	36	-	28	-	26	-	25	**372**
			ITA	32	36	38	27	47	50	26	37	29	25	12	15	13	**387**
			U.S.	50	50	50	50	50	50	50	50	50	50	25	25	25	**575**
Study II	*N*	Total		-	-	50	50	50	42	50	46	50	43	-	-	-	**381**
	Sex	Girls		-	-	28	32	28	19	26	26	29	22	-	-	-	**210**
		Boys		-	-	22	18	22	23	24	20	21	21	-	-	-	**171**
	Mat.Ed.	Lower		-	-	19	18	14	19	20	16	16	17	-	-	-	**139**
		Middle		-	-	14	19	15	11	16	13	17	10	-	-	-	**115**
		Higher		-	-	17	13	21	12	14	17	17	16	-	-	-	**127**
	TV	1		-	-	15	20	17	15	16	15	17	11	-	-	-	**126**
		2		-	-	35	30	33	27	34	31	33	32	-	-	-	**255**

	Computer	1	-	-	22	24	20	15	14	10	9	7	-	-	-	**121**
		2	-	-	12	11	11	13	15	11	7	8	-	-	-	**88**
		3	-	-	11	9	11	10	8	10	17	11	-	-	-	**87**
		4	-	-	5	6	8	4	13	15	17	17	-	-	-	**85**
	Reading	1	-	-	15	9	10	8	6	7	6	6	-	-	-	**67**
		2	-	-	18	22	15	17	17	9	18	20	-	-	-	**136**
		3	-	-	12	7	14	6	14	12	11	8	-	-	-	**84**
		4	-	-	5	12	11	11	13	18	15	9	-	-	-	**94**
Study III	*N*	Total	92	92	97	89	-	-	-	-	-	-	-	-	-	**370**
	Sex	Girls	49	53	54	47	-	-	-	-	-	-	-	-	-	**203**
		Boys	43	39	43	42	-	-	-	-	-	-	-	-	-	**167**

Note. FIN = Finnish children, ITA = Italian children, U.S. = U.S. children. In Study I, Finnish, Italian, and U.S. 3–15 year olds; in Study II, U.S. 5–12 year olds; and in Study III, Finnish 3–6 year olds were assessed. In Study I, assessments were not conducted with Finnish 10, 12, and 14 year olds. Maternal education level is included in the analyses for Study II. In Studies I and III, parental education was only included in Expectation Maximization (EM) imputations, not in analyses, due to the study designs and differences in collected data among the countries. The maternal education variable in Study II denotes: Lower = maximum 12 years of education, Middle = 13–15 years, and Higher = 16 or more years. The media use variables in Study II denote TV watching: 1 = 0–1 hr/day, 2 = 2 or more hr/day; computer use 1 = 0–1 hr/week, 2 = 1.1–2.5 hr/week, 3 = 2.6–4.5 hr/week, 4 = more than 4.5 hr/week; and reading: 1 = less than 2 hr/week, 2 = 2.0–3.5 hr/week, 3 = 3.51–5.5 hr/week, 4 = more than 5.5 hr/week.

the age of the child. The different subtests require different responses from the children. For instance, in some, the children are required to give a verbal answer, in others, the children are asked to respond by pointing to pictures in a booklet, to arrange materials—such as cards—or to build with blocks or draw according to specific rules. The assessment was an interactive situation. Specific descriptions of the administration and scoring instructions of the included subtests are presented in the NEPSY-II administration manuals (Korkman, et al., 2007a, 2008a, 2011a). The subtests and domains included in the three studies are shown in Table 3.

Included age groups as well as subtests and domains differed among Studies I–III because of differences in data and research questions. As a general rule, all suitable subtests were always included. Due to the large number of subtests, domain scores were used in Studies II and III, thus reducing the number of variables. Background variables were included when possible in accordance with the research questions. In the following sections, the included subtests and background variables are presented.

3.2.1 THE COUNTRY STUDY (STUDY I)

In Study I, 10 subtests from the domains Language, Memory and Learning, Social Perception, and Visuospatial Processing of NEPSY-II were selected. Of the raw scores of the subtests, the percentages of the maximum scores for each child were calculated and used. As shown in Table 2, some differences, such as age ranges and administration and scoring procedures, were present among the NEPSY-II versions of the three countries (Finland, Italy, and the United States). Not all subtests were included or renormed in all countries. A subtest was included in Study I if NEPSY-II data was available from all three countries and if it was presented to 3–15 or 5–15-year-old children in a comparable way. Thus, several NEPSY-II subtests were not included in the analyses. Excluded subtests were Animal Sorting, Auditory Attention and Response Set, Clocks, Inhibition, Statue, Visual Attention, Design Fluency, Body Part Naming, Speeded Naming, Repetition of Nonsense Words, Oromotor Sequences, Memory for Designs, Narrative Memory, Sentence Repetition, Word List Interference, List Memory, Visuomotor Precision, Finger Tip Tapping, Imitating Hand Positions, Finger Discrimination, Manual Motor Sequences, Picture Puzzles, and Route Finding. Some subtests were modified to be comparable (see the Data Preparation section 3.5.1.).

Table 2 *NEPSY-II Subtests per Domain; Included in the Three Country Versions, Age Groups Presented To, and Similarities and Differences Among Versions.*

Subtest	Included in Country Version FIN	ITA	U.S.	Age Group	Similarities/Differences
ATTENTION/ EXECUTIVE FUNCTIONING					
Animal Sorting	Yes	Yes	Yes	7–16	Different maximum scores
Auditory Attention	Yes	Yes	Yes	5–16	Different scoring
Response Set	Yes	Yes	Yes	7–16	Different scoring
Clocks	Yes	Yes	Yes	7–16	Different scoring (minor)
Inhibition	Yes	Yes	Yes	5–16	Different procedure (minor)
Statue	Yes	Yes	Yes	3–6	Similar
Visual Attention	Yes	Yes	No	3–16 (FIN, ITA)	Similar
Design Fluency	Yes	Yes	Yes[a]	5–12 (U.S.) 5–16 (FIN, ITA)	Similar
LANGUAGE					
Body Part Naming/Identification	Yes	Yes	Yes	3–4	Difference in presentation
Comprehension of Instructions	Yes	Yes	Yes	3–16	Different discontinuation rule
Phonological Processing	Yes	Yes	Yes	3–16	Different number of items, maximum score, and starting and stopping points
Speeded Naming	Yes	Yes	Yes	3–16	Different maximum time limit and reverse rule
Repetition of Nonsense Words	No	Yes	Yes[a]	5–12 (U.S.) 5–16 (ITA)	Similar
Oromotor Sequences	No	Yes	Yes[a]	3–12 (U.S.) 3–16 (ITA)	Similar
Word Generation	Yes	Yes	Yes[b]	3–16	Differences in scoring (minor)
MEMORY					
Memory for Designs (Delayed)	Yes	Yes	Yes	3–16 (Imm.) / 5–16 (Del.)	Similar
Memory for Faces (Delayed)	Yes	Yes	Yes	5–16	Similar
Memory for Names (Delayed)	Yes	Yes	Yes[b]	5–16	Different max score for ages 5–6
Narrative Memory	Yes	Yes	Yes	3–16	Different maximum scores for ages 3–4 and 11–16, and scoring

(Continued)

Table 2 *(Continued)*

Subtest	Included in Country Version FIN	ITA	U.S.	Age Group	Similarities/Differences
Sentence Repetition	Yes	Yes	Yes	3–6 (FIN, U.S.) 3–16 (ITA)	Similar
Word List Interference	Yes	Yes	Yes	7–16	Similar
List Memory	No	Yes	Yes[a]	7–12 (U.S.) 7–16 (ITA)	Similar
SENSORIMOTOR					
Finger Tip Tapping	Yes	Yes	Yes	5–16	Similar
Imitating Hand Positions	Yes	Yes	Yes[a]	3–12 (U.S.) 3–16 (FIN, ITA)	Similar
Finger Discrimination	Yes	No	No	5–16	*na*
Manual Motor Sequences	No	Yes	Yes[a]	3–12 (U.S.) 3–16 (ITA)	Similar
Visuomotor Precision	Yes	Yes	Yes	3–12 (U.S.) 3–16 (FIN, ITA)	Similar; Difference in scoring (minor)
SOCIAL PERCEPTION					
Affect Recognition	Yes	Yes	Yes	3–16	Different scoring and maximum score
Theory of Mind	Yes	Yes	Yes	3–16	Different scoring and maximum score
VISUOSPATIAL PROCESSING					
Arrows	Yes	Yes	Yes	5–16	Similar
Block Construction	Yes	Yes	Yes	3–16	Similar
Design Copying	Yes	Yes	Yes	3–16	Different starting points; and stop, reverse, and discontinuation rules; and scoring (minor)
Geometric Puzzles	Yes	Yes	Yes	3–16	Different discontinuation rule
Picture Puzzles	Yes	Yes	Yes	7–16	Different scoring, maximum score and discontinuation rule
Route Finding	No	Yes	Yes[a]	5–12 (U.S.) 5–16 (ITA)	Similar

Note. FIN = Finnish version, ITA = Italian version, U.S. = U.S. version; Imm. = Immediate, Del. = Delayed. In addition to the mentioned similarities and differences among the country versions, some differences in stimulus material and order of items may exist, as well as some language differences. These are not included in the present table. In addition, for several subtests, the Italian and U.S. versions had additional scoring possibilities (e.g., contrast and process scores), not present in the Finnish version. For more information regarding similarities and differences among the subtests, see the Finnish and Italian assessment manuals (Korkman, et al., 2008b, 2011a).

[a] Subtests in the U.S. standardization not renormed for NEPSY-II (Korkman, Kirk, & Kemp, 2007b).

[b] Subtests in the U.S. standardization partly renormed for NEPSY-II (Korkman, et al., 2007b).

3.2.2 THE MEDIA STUDY (STUDY II)

In Study II, domain scores from the U.S. NEPSY-II were used. When consisting of at least two subtests, the means of 20 subtests (some including two or more separate scores; see Table 3) were calculated into domain scores. A subtest was included in the domains when it was included in the assessment battery for 5–12-year-old children. Some of the subtests were presented only to 5–6 year olds or 7–12 year olds, due to the design of NEPSY-II. Such differences were accounted for because scaled scores of the subtests were used (M = 10, SD = 3).

3.2.3 THE EMOTION RECOGNITION STUDY (STUDY III)

In Study III, raw scores of the NEPSY-II Affect Recognition subtest were used to investigate the relationship of the subtest with age. Scaled scores of the Affect Recognition subtest and domain scores consisting of the mean of scaled scores of 14 subtests from the Finnish version of NEPSY-II were used for investigating the relationship between emotion recognition and other neurocognitive functions. The Theory of Mind subtest was included in the analyses of the domains, because the only other subtest in the Social Perception domain, the Affect Recognition subtest, was the dependent variable.

The ability to recognize facial expressions of emotions was assessed with the Affect Recognition subtest. In the subtest, color photographs of children depicting different emotions (happiness, sadness, anger, disgust, fear, and neutral) are used. In four tasks (for 3–6 year olds), the child is asked to select pictured children who “feel the same way” —that is, depict the same emotion. The child answers with a yes/no in the first task of the subtest. Otherwise, only non-verbal responses are required.

Table 3 *The NEPSY-II Subtests and Domains Included in the Three Studies and Minimums, Maximums, Means, and Standard Deviations of the Scores.*

Domain / Subtest Name	Age Group	Min Score	Max Score	*M*	*SD*
			Study I		
Language	***na***	***na***	***na***	***na***	***na***
Comprehension of Instructions	3–15	1	33	22.82	6.34
Phonological Processing	5–15	0	45 / 53[a]	40.42	9.42
Memory and Learning	***na***	***na***	***na***	***na***	***na***
Memory for Faces Immediate	5–15	1	16	10.64	2.69
Memory for Faces Delayed	5–15	0	16	10.38	3.06
Social Perception	***na***	***na***	***na***	***na***	***na***
Affect Recognition	3–15	0	35 / 45[b]	21.36	8.13
Theory of Mind	3–15	0	25 / 28[c]	18.10	6.59
Visuospatial Processing	***na***	***na***	***na***	***na***	***na***
Arrows	5–15	0	38	25.02	8.09
Block Construction	3–15	0	28	13.67	5.98
Design Copying (General)	3–15	0	21	9.80	5.14
Geometric Puzzles	3–15	0	40	23.30	8.43
			Study II		
Attention and Executive Functioning	**5–12**	**3.81**	**13.88**	**10.09**	**1.80**
Animal Sorting	7–12	3	18	10.43	2.83
Auditory Attention	5–12	1	15	10.20	2.85
Response Set	7–12	2	16	9.95	3.01
Clocks	7–12	1	19	10.25	3.10
Inhibition Naming	5–12	1	19	10.16	2.94
Inhibition Inhibition	5–12	1	17	9.90	2.89
Inhibition Switching	7–12	1	18	10.04	2.94
Inhibition Errors	5–12	1	18	9.79	2.94
Statue	5–6	3	14	10.40	3.07
Language	**5–12**	**2.67**	**15.00**	**10.15**	**2.14**
Comprehension of Instructions	5–12	1	17	10.18	2.98
Phonological Processing	5–12	1	17	10.14	2.84
Speeded Naming Time	5–12	2	17	10.12	2.90
Memory and Learning	**5–12**	**5.13**	**13.86**	**10.10**	**1.64**
Memory for Designs Immediate	5–12	3	19	10.09	2.89
Memory for Designs Delayed	5–12	4	19	10.07	2.90
Memory for Faces Immediate	5–12	3	17	10.00	2.97
Memory for Faces Delayed	5–12	3	17	10.23	2.85
Narrative Memory	5–12	2	18	10.14	3.01
Sentence Repetition	5–6	4	17	9.94	2.79
Word List Interference Repetition	7–12	1	18	10.17	3.02
Word List Interference Recall	7–12	2	19	10.08	3.02
Social Perception	**5–12**	**3.64**	**15.30**	**10.04**	**2.30**
Affect Recognition	5–12	3	16	10.12	3.00
Theory of Mind	5–12	1	17	9.95	3.00

(Continued)

Table 3 (*Continued)*

Domain / Subtest Name	Age Group	Min Score	Max Score	*M*	*SD*
Visuospatial Processing	**5–12**	**4.72**	**14.86**	**10.22**	**1.85**
Arrows	5–12	2	18	10.17	2.66
Block Construction	5–12	2	18	10.26	2.71
Design Copying	5–12	1	19	10.34	2.96
Geometric Puzzles	5–12	2	18	9.99	2.97
Picture Puzzles	7–12	3	18	10.45	2.85
Study III					
Attention and Executive Functioning	**3–6**	**3**	**15**	**10.03**	**2.14**
Statue	3–6	1	15	10.02	2.90
Visual Attention	3–6	1	18	10.04	2.81
Language	**3–6**	**4**	**16**	**10.01**	**2.06**
Comprehension of Instructions	3–6	1	19	10.00	2.99
Phonological Processing	3–6	1	19	10.03	2.82
Word Generation	3–6	5	19	9.99	2.96
Memory and Learning	**3–6**	**1**	**16**	**10.00**	**2.29**
Memory for Designs	3–6	1	19	10.00	2.98
Sentence Repetition	3–6	1	18	10.00	2.98
Sensorimotor	3–6	2	17	9.89	2.33
Imitating Hand Positions	3–6	1	17	10.01	2.97
Visuomotor Precision	3–6	2	18	9.78	3.08
Social Perception	**3–6**	**na**	**na**	**na**	**na**
Affect Recognition (raw score)	3–6	0	23	12.76	5.20
Affect Recognition (scaled score)	3–6	1	17	10.01	2.96
Theory of Mind A	3–6	1	18	10.01	2.96
Theory of Mind B	3–6	3	19	10.00	2.98
Theory of Mind (A and B combined)	3–6	3	18	10.00	2.25
Visuospatial Processing	**3–6**	**3**	**18**	**10.00**	**2.38**
Block Construction	3–6	1	19	10.00	2.98
Design Copying	3–6	1	19	10.00	2.99

Note. The names of the domains are presented in boldface. In Study I, percentages of maximum raw scores were used in the analyses, but here, raw scores are presented. In Studies II and III, scaled scores were used (constructed to have a mean of 10 and a standard deviation of 3), and these were included in domain scores (means of the subtests). In Study III, the raw score of the Affect Recognition subtest was also used. The age group indicates which of the two separate analyses (3–15 or 5–15 year olds) the subtest was included in (Study I) or which age group the subtest was given to (Studies II and III).

[a] Phonological Processing: The U.S. maximum score of 45 was converted to 53 to be comparable with the score of the other countries.

[b] Affect Recognition: The Finnish maximum score of 45 was converted to 35 to be comparable with the score of the other countries.

[c] Theory of Mind: The Finnish and Italian maximum scores were 25, and the U.S. maximum score was 28.

3.3 MEDIA USE

In Study II, habits of media use, as reported by parents, were collected through a home environment questionnaire. The questionnaire was developed at Pearson and contained 56 questions about different aspects relating to the background, habits, and environment of the child. In Study II, four questions measuring time spent watching TV, using a computer, and reading were included. These are presented in Table 4. For the media variables, raw scores were used in the analyses. The media variables were categorized to be adequate for analyses (see section 3.5.1. Data Preparation section).

Table 4 *The Four Questions of the Home Environment Questionnaire Selected for the Present Study.*

How many hours per day does the child watch TV?	0	1	2–3	4–5	6 or more
Is the child allowed to use the computer?	Y	N			
If applicable, how many hours per week does the child use the computer for each of the following?	Homework __ hrs	Playing Games __ hrs		Internet __ hrs	Other:___ __ hrs
How many hours per week does the child read at home?	____ hours per week				

3.4 AGE, SEX, AND PARENTAL EDUCATION

Background information was collected for the participants in connection with the assessments in the separate countries. In Study I, the age and sex of the child were used as background variables and were included in analyses. Parental education level was included in the Expectation Maximization (EM) imputation as an indication of socioeconomic status. The educational level was measured differently and was not available for all children in all three countries. Hence, this variable was not included in the analyses.

In Study II, age, sex, and maternal education levels of the U.S. children were included in the analyses. In order to investigate the possible moderating effect of age on the relationship between media use and neurocognitive performance, age was included. The initial eight maternal educational levels reported on the home environment questionnaire were combined into three categories: high school graduate or equivalent or high school dropout (maximum 12 years of education), some college or an Associate's degree (13–15 years of education), and a college degree or further education (16 or more years of education). For descriptives of the maternal education levels, see Table 1.

In Study III, age, sex, and parental education levels of the Finnish children were provided by parents on a background information questionnaire. In the analyses, the age of the child was included. Sex, as well as maternal and paternal education levels, were included in the EM imputation.

3.5 STATISTICAL ANALYSES

In Studies I–III, the data were studied using different General Linear Model (GLM) analyses. Prior to analyses, the data were prepared. Missing values on the subtests were imputed using EM imputation in all studies. In Study II, missing data on the media variables were imputed using the same method. Prior to analyses, bivariate correlations were inspected in all three studies, with all included NEPSY-II subtests and/or domains significantly correlating with each other in all three studies (p < .001). All tests of significance were two-tailed and significance level was pre-specified to p < .05. Effect sizes were indicated using partial eta squared (η_p^2) and standardized mean difference (d). Values of η_p^2 = .01 and d = 0.20 were considered to indicate a small effect, values of η_p^2. = .06 and d = 0.50 indicated a medium effect, and values of η_p^2 = .14 and d = 0.80 indicated a large effect (Cohen, 1988). Pairwise comparisons of means were corrected using Bonferroni (Studies I and II) and Tukey's methods (Study III). Below, the data procedures (preparation and analyses), specific for the three studies, are explained in more detail.

3.5.1 DATA PREPARATION

In Study I, the Finnish, Italian, and U.S. NEPSY-II versions were compared for maximum scores, stimuli, and administration rules (i.e., points for starting and finishing, or rules for discontinuation and reversing). Most of the included subtests were comparable among the countries, but when needed and possible, scores were transformed to ensure comparability. Such preparations were conducted for the Affect Recognition (the Finnish scores were rescored on the item level) and Phonological Processing subtests (points were added to the total score of the U.S. 5–15 year olds). The maximum score for the Theory of Mind subtest differed between the U.S. and European data. This divergence was met by using the percentage of the maximum scores. There were also some smaller differences in starting points, and discontinuation and reverse rules for the Comprehension of Instructions, Geometric Puzzles, and Design Copying subtests among the country versions. For some subtests, there were differences in the order of item presentation or differences in stimulus pictures. However, in all, after inspection of the data and results, these subtests were considered comparable among the countries. Finally, the percentage of the maximum subtest raw scores were calculated for all subtests.

In Study II, the media variables were prepared and categorized to make the groups as similarly sized as possible and to be adequate for analysis. The final groups differed among various media due to differences in the questionnaire and distribution of data. For the TV watching variable, two groups were formed: children watching daily TV less (0–1 hour/day) or more (2 or more hours/day).

The computer-use and reading variables were divided into four categories each, with children using the computer for 0–1 hours/week, 1.1–2.5 hours/week, 2.6–4.5 hours/week, and more than 4.5 hours/week, and children reading for less than 2 hours/week, 2.0–3.5 hours/week, 3.5–5.5 hours/week, and more than 5.5 hours/week. For the media questions included in the study, see Table 4, and for descriptives of each media variable per age group, see Table 1.

In Study III, subtest raw scores were converted into scaled scores (M = 10, SD = 3). Then, the means of the scaled scores were calculated into domain scores in accordance with the manual.

3.5.2 DATA ANALYSES

In Study I, two MANOVAs were run separately for the subtests given to the 3–15 year olds and 5–15 year olds, with age, country, and sex as between-subject factors. Then, separate univariate ANOVAs were performed for each subtest. The age, country, and sex main effects, as well as the age and country interaction, were investigated. Bonferroni-corrected pairwise comparisons were conducted for the scores among the countries, for all age groups separately. For these, effect sizes *d* were calculated.

In Study II, GLM analyses were run for each neurocognitive domain separately. In each analysis, factors were all the media variables, as well as maternal education and sex. Age was included as a covariate. First, analyses were run with all possible two-way interactions, and the final models were reached using sequential backwards elimination. Bonferroni-corrected pairwise comparisons were conducted for significant findings, with effect size *d*.

In Study III, an ANOVA was run with age and the Affect Recognition subtest (raw score). Tukey's post hoc tests were used as an indication of effects among age groups, and trends in the data were investigated with polynomial contrasts. Linear regression analysis was used to investigate the relationship between the neurocognitive domains/subtest and the Affect Recognition subtest (scaled scores). A commonality analysis was run (Nimon, 2010), indicating shared and unique variance of the Affect Recognition subtest. This was preceded by regression analyses with backward eliminations.

4 RESULTS

4.1 DIFFERENCES BETWEEN THREE COUNTRIES

Neurocognitive performance improved significantly with age in all three countries—Finland, Italy, and the United States—for both age groups (3–15 and 5–15). The main effects of country and sex and the interaction of country and age were significantly related to the NEPSY-II variables. The results of the two MANOVAs are shown in Table 5. The result of the separate ANOVAs are presented in Table 6 for each main effect and the interaction. All neurocognitive functions were related to age, and most subtests were related to the sex of the child. Girls generally scored higher than boys, except in the subtests Arrows and Block Construction, where the opposite was true. Most subtests were significantly related to the country variable and to its interaction with age. The developmental curves of the subtests are presented in the original article (Study I). The significant Bonferroni-corrected pairwise comparisons are presented in Table 7, together with effect sizes d (d_1), for which the estimate of standard deviation was calculated as the square root of (SS_{error} + SS_{sex} + SS_{age} + SS_{country} × age) / (df_{error} + df_{sex}+ df_{age} + df_{country} × age). Generally, with several independent variables, it is ideal to include effects other than the one of interest to the estimation of standard deviation when calculating effect size d (Grissom & Kim, 2012). However, because age had a large influence on the subtest performance, and the age variation in Study I was broad; including age could shrink the effect size excessively in d_1. Hence, the standard deviation estimate of the effect size (d_2) was also calculated without the age variable—as square root of (SS_{error}+SS_{sex}) / (df_{error} + df_{sex}).

Table 5 *The Results of the Two Separate MANOVAs for the Two Age Groups.*

Variable	Age Group	Wilk's Λ	*F*	*df*	*p*	η_p^2
Age	3–15	0.06	134.15	72; 14712	< .001	0.37
	5–15	0.22	101.77	40; 8261	< .001	0.32
Country	3–15	0.62	123.81	12; 5406	< .001	0.22
	5–15	0.95	12.97	8; 4356	< .001	0.02
Sex	3–15	0.95	24.52	6; 4356	< .001	0.05
	5–15	0.95	28.84	4; 2178	< .001	0.05
Country × Age	3–15	0.68	8.68	126; 15682	< .001	0.06
	5–15	0.88	4.35	68; 8549	< .001	0.03

Table 6 *The Result of the ANOVAs for Each Main Effect and the Interaction.*

Variable	Subtest	Age Group	Type IV Sum of Squares	*df*	Mean Square	*F*	*p*	η_p^2
Age	AR	3–15	1,037,253.40	12	86,437.78	747.74	< .001	.77
	BC	3–15	854,710.06	12	71,225.84	609.41	< .001	.73
	CI	3–15	663,961.96	12	55,330.16	539.81	< .001	.71
	DC	3–15	1,074,029.12	12	89,502.43	719.34	< .001	.76
	GP	3–15	860,530.73	12	71,710.89	794.19	< .001	.78
	TM	3–15	1,177,771.36	12	98,147.61	843.48	< .001	.79
	AW	5–15	581,855.00	10	58,185.5	335.55	< .001	.61
	MFI	5–15	176,043.70	10	17,604.37	89.36	< .001	.29
	MFD	5–15	236,019.80	10	23,601.98	95.24	< .001	.30
	PH	5–15	467,663.03	10	46,766.3	532.12	< .001	.71
Sex	AR	3–15	3,809.25	1	3,809.251	32.95	< .001	.01
	BC	3–15	2,357.44	1	2,357.435	20.17	< .001	.01
	CI	3–15	1,378.71	1	1,378.712	13.45	< .001	.01
	DC	3–15	5,598.77	1	5,598.768	45.00	< .001	.02
	GP	3–15	12.38	1	12.376	0.14	.711	.00
	TM	3–15	2,816.22	1	2,816.219	24.20	< .001	.01
	AW	5–15	10,824.6	1	10,824.63	62.42	< .001	.03
	MFI	5–15	3,200.45	1	3,200.449	16.25	< .001	.01
	MFD	5–15	6,311.66	1	6,311.661	25.47	< .001	.01
	PH	5–15	71.55	1	71.554	0.81	.367	.00
Country	AR	3–15	12,253.17	2	6,126.586	53.00	< .001	.04
	BC	3–15	2,851.04	2	1,425.521	12.20	< .001	.01
	CI	3–15	13,850.20	2	6,925.099	67.56	< .001	.05
	DC	3–15	152,396.38	2	76,198.19	612.41	< .001	.31
	GP	3–15	9,151.70	2	4,575.852	50.68	< .001	.04
	TM	3–15	1,179.38	2	589.688	5.07	.006	.00
	AW	5–15	7,381.85	2	3,690.927	21.29	< .001	.02
	MFI	5–15	952.09	2	476.046	2.42	.089	.00
	MFD	5–15	1,033.49	2	516.746	2.09	.125	.00
	PH	5–15	2,865.63	2	1,432.816	16.30	< .001	.02

(Continued)

Table 6 *(Continued)*

Variable	Subtest	Age Group	Type IV Sum of Squares	*df*	Mean Square	*F*	*p*	η_p^2
Country × Age	AR	3–15	22,845.98	21	1,087.904	9.41	< .001	.07
	BC	3–15	6,140.05	21	292.383	2.50	< .001	.02
	CI	3–15	3,885.02	21	185.001	1.81	.014	.01
	DC	3–15	44,782.50	21	2,132.5	17.14	< .001	.12
	GP	3–15	30,877.57	21	1,470.361	16.28	< .001	.11
	TM	3–15	13,480.05	21	641.907	5.52	< .001	.04
	AW	5–15	7,752.64	17	456.037	2.63	< .001	.02
	MFI	5–15	7,405.73	17	435.631	2.21	.003	.02
	MFD	5–15	4,586.95	17	269.82	1.09	.358	.01
	PH	5–15	16,141.96	17	949.527	10.80	< .001	.08

Note. AR = Affect Recognition, BC = Block Construction, CI = Comprehension of Instructions, DC = Design Copying, GP = Geometric Puzzles, TM = Theory of Mind, AW = Arrows, MFI = Memory for Faces Immediate, MFD = Memory for Faces Delayed, and PH = Phonological Processing.

As seen in Table 7, significant differences between countries were present for several of the age groups for the subtests Affect Recognition, Comprehension of Instructions, Design Copying, Geometric Puzzles, and Phonological Processing. For the subtests Block Construction, Arrows, and Memory for Faces Immediate and Delayed, fewer age groups showed significant differences in the pairwise comparisons. For the Theory of Mind subtest, significant differences in pairwise comparisons only emerged for the 3–6 year olds, but for these age groups, there were several significant comparisons. Thus, significant differences did not appear for all age groups, and, further, not always between all three countries. Absolute values of effect sizes d, $|d|$ ranged between 0.19 and 1.29 for d_1 and between 0.33 and 2.66 for d_2. Over all, the highest number of significant effects and the largest effect sizes were found for the Design Copying subtest. For the Block Construction, Comprehension of Instruction and Memory for Faces subtests, several of the effect sizes were small.

Looking at the country pairs, most significant differences emerged between the Italian and U.S. data, and these were mostly of large or medium effect sizes. Somewhat fewer significant differences in pairwise comparisons, and fewer differences of large effect sizes, emerged between the Finnish and Italian or Finnish and U.S. data.

Table 7 *Significant Pairwise Comparisons Between the Three Countries and Effect Sizes d for Each Age Group.*

Subtest	Age	Country Comparison	Mean Difference	*SE*	*p*	d_1	d_2
AR	3	Finland – Italy	-6.92	1.74	< .001	-0.31	-0.64
		Italy – USA	4.57	1.75	.027	0.20	0.42
	5	Italy – USA	-5.63	1.58	< .001	-0.25	-0.52
	7	Finland – Italy	-13.13	1.66	< .001	-0.59	-1.21
		Italy – USA	14.42	1.59	< .001	0.64	1.33
	8	Finland – Italy	-12.71	1.67	< .001	-0.57	-1.17
		Finland – USA	4.58	1.68	.019	0.20	0.42
		Italy – USA	17.28	1.52	< .001	0.77	1.60
	9	Finland – Italy	-6.81	1.91	.001	-0.30	-0.63
		Italy – USA	9.97	1.76	< .001	0.44	0.92
	10	Italy – USA	6.07	1.67	< .001	0.27	0.56
	11	Finland – USA	4.72	1.70	.017	0.21	0.44
		Italy – USA	7.67	1.85	< .001	0.34	0.71
	12	Italy – USA	5.77	1.90	.002	0.26	0.53
BC	5	Finland – Italy	6.25	1.57	< .001	0.30	0.58
		Italy – USA	-3.96	1.59	.038	-0.19	-0.37
	6	Finland – USA	4.45	1.54	.011	0.21	0.41
	7	Finland – USA	5.58	1.61	.002	0.27	0.51
		Italy – USA	4.85	1.60	.007	0.23	0.45
	8	Finland – USA	4.63	1.69	.018	0.22	0.43
	11	Finland – USA	4.31	1.71	.035	0.21	0.40
		Italy – USA	7.41	1.86	< .001	0.36	0.68
CI	3	Finland – Italy	-4.12	1.64	.037	-0.22	-0.41
		Italy – USA	4.92	1.65	.008	0.26	0.48
	4	Finland – USA	4.84	1.44	.002	0.26	0.48
		Italy – USA	4.76	1.55	.007	0.26	0.47
	5	Finland – Italy	5.84	1.47	< .001	0.31	0.58
		Finland – USA	7.34	1.41	< .001	0.40	0.72
	6	Finland – USA	7.65	1.44	< .001	0.41	0.75
		Italy – USA	6.56	1.77	< .001	0.35	0.65
	7	Finland – USA	7.00	1.50	< .001	0.38	0.69
		Italy – USA	4.89	1.50	.003	0.26	0.48
	8	Finland – USA	7.70	1.58	< .001	0.41	0.76
		Italy – USA	4.40	1.43	.006	0.24	0.43
	9	Finland – USA	5.71	1.59	.001	0.31	0.56
	11	Finland – USA	7.21	1.60	< .001	0.39	0.71
		Italy – USA	5.28	1.74	.007	0.28	0.52

(Continued)

Table 7 *(Continued)*

Subtest	Age	Country Comparison	Mean Difference	*SE*	*p*	d_1	d_2
DC	3	Finland – Italy	-11.93	1.81	< .001	-0.52	-1.06
		Italy – USA	9.20	1.81	< .001	0.40	0.82
	4	Finland – Italy	-7.63	1.72	< .001	-0.33	-0.68
		Italy – USA	9.00	1.71	< .001	0.39	0.80
	5	Finland – Italy	-5.62	1.62	.002	-0.24	-0.50
		Finland – USA	4.66	1.55	.008	0.20	0.41
		Italy – USA	10.28	1.64	< .001	0.45	0.91
	6	Finland – Italy	-8.29	1.95	< .001	-0.36	-0.74
		Finland – USA	4.74	1.59	.009	0.21	0.42
		Italy – USA	13.03	1.95	< .001	0.56	1.16
	7	Finland – Italy	-4.45	1.73	.030	-0.19	-0.40
		Finland – USA	13.37	1.66	< .001	0.58	1.19
		Italy – USA	17.81	1.65	< .001	0.77	1.58
	8	Finland – USA	16.66	1.74	< .001	0.72	1.48
		Italy – USA	17.34	1.57	< .001	0.75	1.54
	9	Finland – USA	19.33	1.75	< .001	0.84	1.72
		Italy – USA	16.69	1.82	< .001	0.72	1.48
	10	Italy – USA	23.19	1.73	< .001	1.00	2.06
		Finland – USA	25.14	1.76	< .001	1.09	2.24
		Italy – USA	28.75	1.92	< .001	1.25	2.56
	12	Italy – USA	23.08	1.97	< .001	1.00	2.05
	13	Finland – USA	21.16	2.12	< .001	0.92	1.88
		Italy – USA	19.95	2.66	< .001	0.86	1.77
	14	Italy – USA	29.86	2.77	< .001	1.29	2.66
	15	Finland – USA	20.19	2.08	< .001	0.87	1.80
		Italy – USA	22.61	2.38	< .001	0.98	2.01
GP	3	Finland – Italy	-4.62	1.54	.008	-0.23	-0.49
		Italy – USA	4.31	1.54	.016	0.21	0.45
	4	Finland – Italy	6.78	1.47	< .001	0.33	0.71
		Italy – USA	-5.42	1.46	.001	-0.27	-0.57
	5	Finland – Italy	4.03	1.38	.010	0.20	0.42
	6	Finland – Italy	17.87	1.66	< .001	0.88	1.88
		Italy – USA	-17.33	1.66	< .001	-0.85	-1.82
	7	Finland – Italy	17.32	1.47	< .001	0.85	1.82
		Finland – USA	5.02	1.41	.001	0.25	0.53
		Italy – USA	-12.30	1.41	< .001	-0.60	-1.29
	8	Finland – Italy	14.39	1.48	< .001	0.71	1.51
		Italy – USA	-11.14	1.34	< .001	-0.55	-1.17
	9	Finland – Italy	12.09	1.68	< .001	0.59	1.27
		Italy – USA	-9.85	1.55	< .001	-0.48	-1.04
	12	Italy – USA	4.92	1.68	.003	0.24	0.52
	13	Finland – Italy	6.40	2.19	.011	0.31	0.67

(Continued)

Table 7 *(Continued)*

Subtest	Age	Country Comparison	Mean Difference	*SE*	*p*	d_1	d_2
GP	14	Italy – USA	8.28	2.36	< .001	0.41	0.87
	15	Finland – USA	5.44	1.77	.006	0.27	0.57
		Italy – USA	5.00	2.03	.041	0.25	0.53
TM	3	Finland – Italy	-7.97	1.75	< .001	-0.34	-0.74
		Italy – USA	4.76	1.75	.020	0.20	0.44
	4	Finland – Italy	-6.33	1.67	< .001	-0.27	-0.58
		Italy – USA	7.15	1.65	< .001	0.30	0.66
	5	Finland – Italy	11.31	1.56	< .001	0.48	1.04
		Finland – USA	5.85	1.50	< .001	0.25	0.54
		Italy – USA	-5.46	1.59	.002	-0.23	-0.50
	6	Finland – USA	5.65	1.53	< .001	0.24	0.52
AW	5	Finland – Italy	4.85	1.91	.033	0.23	0.36
		Finland – USA	5.67	1.83	.006	0.27	0.42
	6	Finland – Italy	13.86	2.30	< .001	0.66	1.04
		Finland – USA	6.41	1.87	.002	0.30	0.48
		Italy – USA	-7.45	2.30	.004	-0.35	-0.56
	8	Finland – USA	7.45	2.05	.001	0.35	0.56
	10	Italy – USA	-6.32	2.04	.002	-0.30	-0.47
MFI	5	Finland – USA	-4.69	1.95	.049	-0.28	-0.33
	6	Finland – Italy	8.46	2.46	.002	0.51	0.60
		Italy – USA	-7.37	2.45	.008	-0.44	-0.52
	8	Finland – Italy	7.10	2.18	.004	0.42	0.50
MFD	5	Finland – USA	-6.54	2.19	.009	-0.35	-0.41
PH	5	Finland – Italy	5.33	1.36	< .001	0.30	0.57
		Finland – USA	-4.44	1.30	.002	-0.25	-0.47
		Italy – USA	-9.77	1.38	< .001	-0.56	-1.04
	6	Finland – Italy	-4.05	1.64	.041	-0.23	-0.43
		Finland – USA	-5.56	1.33	< .001	-0.32	-0.59
	7	Finland – Italy	-9.00	1.45	< .001	-0.51	-0.96
		Finland – USA	-7.02	1.39	< .001	-0.40	-0.75
	8	Finland – Italy	-4.61	1.46	.005	-0.26	-0.49
		Italy – USA	6.08	1.32	< .001	0.35	0.65
	9	Finland – USA	4.83	1.47	.003	0.28	0.51
		Italy – USA	5.14	1.53	.002	0.29	0.55
	10	Italy – USA	6.28	1.46	< .001	0.36	0.67
	11	Finland – USA	5.99	1.48	< .001	0.34	0.64
		Italy – USA	7.55	1.61	< .001	0.43	0.81
	12	Italy – USA	5.49	1.66	< .001	0.31	0.59

Note. The subtest abbreviations denote AR = Affect Recognition, BC = Block Construction, CI = Comprehension of Instructions, DC = Design Copying, GP = Geometric Puzzles, TM = Theory of Mind, AW = Arrows, MFI = Memory for Faces Immediate, MFD = Memory for Faces Delayed, and PH = Phonological Processing. d_1 = Estimate of *SD* calculated with age, d_2 = Estimate of *SD* calculated without age.

4.2 RELATIONSHIPS WITH MEDIA USE

Each of the NEPSY-II domains were separately analyzed with GLM analyses, including age, maternal education, sex, and the three media variables, using the U.S. standardization data of the NEPSY-II. The results of the analyses can be found in Table 8, including significant Bonferroni-corrected post hoc results. Estimated marginal means of the domains for each medium are shown in Figures 1–3. Age was not significantly related to the NEPSY-II domains, which was expected as the scores were scaled according to age groups. A higher maternal education level was significantly related to better performance for all domains, and girls outperformed boys on the Language and Social Perception domains. As shown in Table 8 and Figures 1–3, TV watching had a negative relationship with all assessed neurocognitive domains. Computer use had a positive relationship with the Language, Memory/Learning, and Social Perception domains. Reading had a positive relationship with performance on the Attention/Executive Functioning and Visuospatial Processing domains. No significant interactions emerged in the TV watching and computer use analyses. For reading, significant interactions with age remained for the Attention/Executive Functioning and Visuospatial Processing domains and a significant interaction with maternal education remained for the Memory/Learning domain (see Figure 4). More time spent reading was related to better performance on tasks of attention/executive function or visuospatial processing in younger children. Further, when maternal education was 12 years or less, children reading more performed better on the Memory and Learning domain compared to children reading less.

Table 8 *The Results of the GLM Analyses, for Each Domain Separately with Significant Post Hoc Comparisons.*

Variable	Sum of Squares	*df*	Mean Square	*F*	*p*	η_p^2	Post Hoc
Attention/Executive Functioning							
TV	12.12	1	12.12	4.15	.042	.01	1 > 2
Comp.	22.53	3	7.51	2.57	.054	.02	*ns*
Read.	40.73	3	13.58	4.65	.003	.04	2 < 4
Age	9.67	1	9.67	3.31	.070	.01	
Sex	5.93	1	5.93	2.03	.165	.01	
M.Ed.	59.24	2	29.62	10.13	< .001	.05	
Read.×Age	28.20	3	9.40	3.22	.023	.03	2 < 4 (5–8yrs) 2 < 3 (6–7yrs)

(Continued)

Table 8 *(Continued)*

Variable	Sum of Squares	*df*	Mean Square	*F*	*p*	η_p^2	Post Hoc
Language							
TV	29.03	1	29.03	7.30	.007	.02	1 > 2
Comp.	46.45	3	15.48	3.90	.009	.03	1 < 3
Read.	19.30	3	6.43	1.62	.185	.01	*ns*
Age	3.14	1	3.14	0.79	.375	.00	
Sex	18.73	1	18.73	4.71	.031	.01	
M.Ed.	111.92	2	55.96	14.08	< .001	.07	
Memory/Learning							
TV	9.53	1	9.53	4.04	.045	.01	1 > 2
Comp.	26.94	3	8.98	3.81	.010	.03	1 < 3
Read.	11.23	3	3.74	1.59	.192	.01	*ns*
Age	0.61	1	0.61	0.26	.611	.00	
Sex	5.86	1	5.86	2.49	.116	.01	
M.Ed.	72.44	2	36.22	15.37	< .001	.08	
Read.×M.Ed.	31.03	6	5.17	2.19	.043	.04	1 < 2; 1 < 3 (Lower M.Ed.)
Social Perception							
TV	40.55	1	40.55	8.82	.003	.02	1 > 2
Comp.	47.89	3	15.96	3.47	.016	.03	1 < 4
Read.	20.33	3	6.78	1.47	.221	.01	*ns*
Age	7.47	1	7.47	1.63	.203	.00	
Sex	59.46	1	59.46	12.93	< .001	.03	
M.Ed.	119.41	2	59.70	12.99	< .001	.07	
Visuospatial Processing							
TV	14.31	1	14.31	4.74	.030	.01	1 > 2
Comp.	10.03	3	3.34	1.11	.347	.01	*ns*
Read.	39.26	3	13.09	4.33	.005	.03	*ns*
Age	0.34	1	0.34	0.11	.738	.00	
Sex	0.00	1	0.00	0.00	.971	.00	
M.Ed.	97.83	2	48.92	16.19	< .001	.08	
Read.×Age	35.12	3	11.71	3.87	.009	.03	1 < 4 (5–7 yrs); 2 < 4 (5–7 yrs)

Note. Abbreviations denote: TV = TV watching, Comp. = Computer use, Read. = Reading, M.Ed. = Maternal education. The media use groups in the post hoc analyses are: TV watching: 1 = 0–1 hr/day, 2 = 2 or more hr/day; Computer use 1 = 0–1 hr/week, 2 = 1.1–2.5 hr/week, 3 = 2.6–4.5 hr/week, 4 = more than 4.5 hr/week; and Reading: 1 = less than 2 hr/week, 2 = 2.0–3.5 hr/week, 3 = 3.51–5.5 hr/week, 4 = more than 5.5 hr/week.

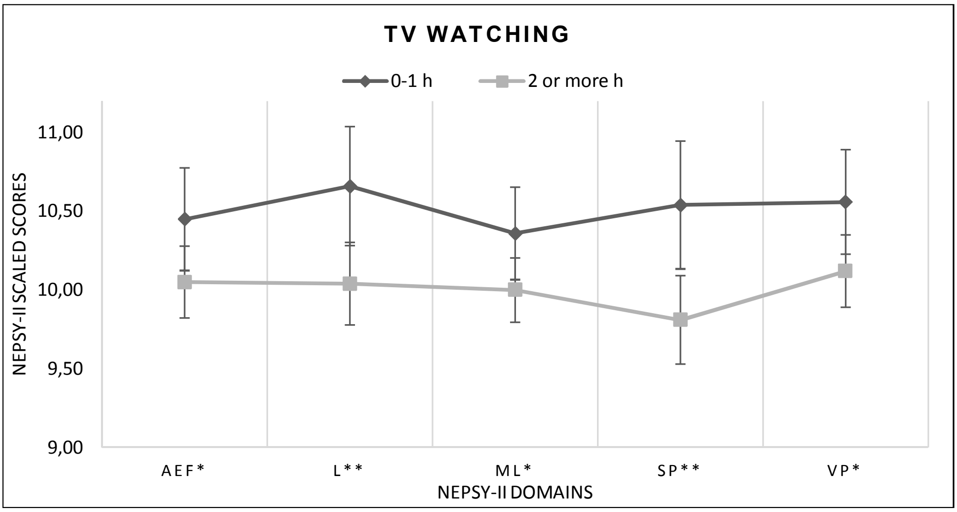

Figure 1 Relationship between daily time spent watching TV and neurocognitive functioning. Estimated marginal means are presented for each domain. Error bars denote ±2 SE (95% confidence interval). AEF = Attention/Executive Functioning, L = Language, ML = Memory/Learning, SP = Social Perception, VP = Visuospatial Processing.
** = p < .01, * = p < .05

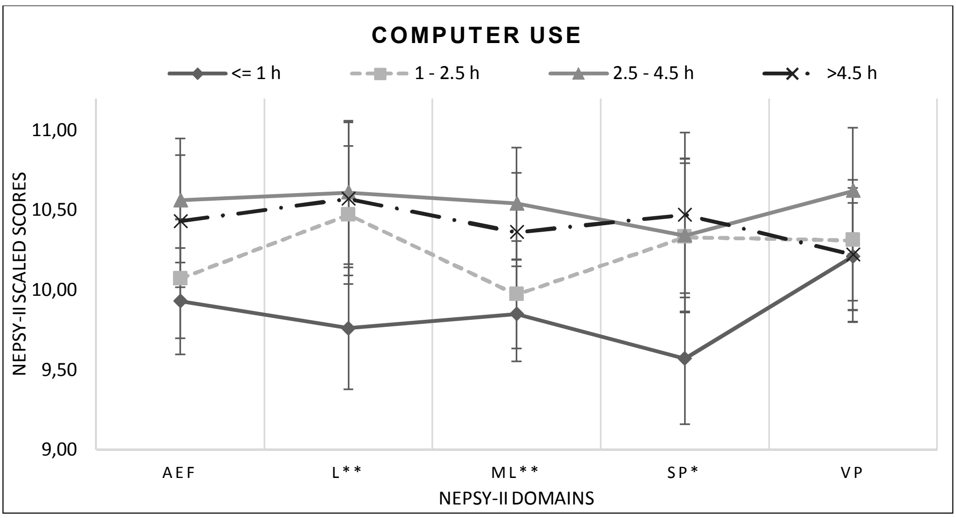

Figure 2 Relationship between weekly time spent using computer and neurocognitive functioning. Estimated marginal means are presented for each domain. Error bars denote ±2 SE (95% confidence interval). AEF = Attention/Executive Functioning, L = Language, ML = Memory/Learning, SP = Social Perception, VP = Visuospatial Processing.
** = p < .01, * = p < .05

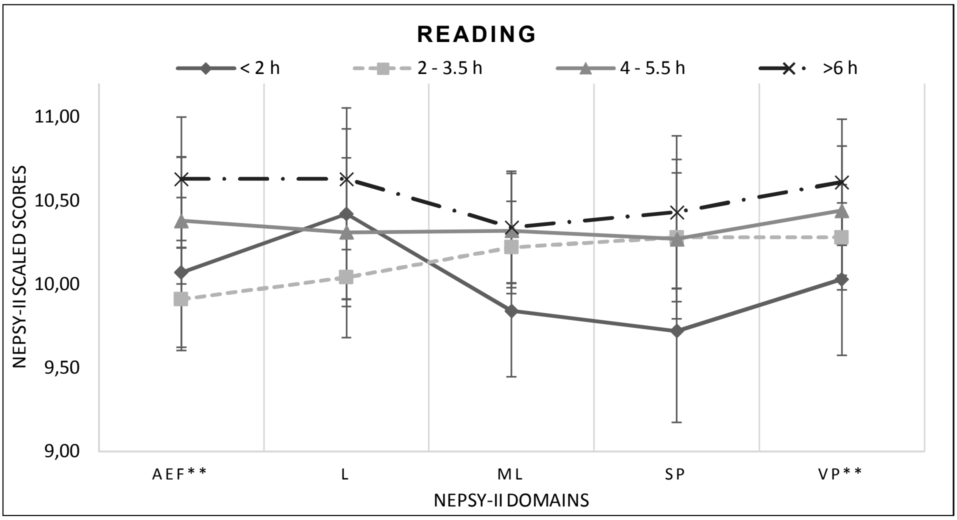

Figure 3 Relationship between weekly time spent reading and neurocognitive functioning. Estimated marginal means are presented for each domain. Error bars denote ±2 SE (95% confidence interval). AEF = Attention/Executive Functioning, L = Language, ML = Memory/Learning, SP = Social Perception, VP = Visuospatial Processing.
** = *p* < .01

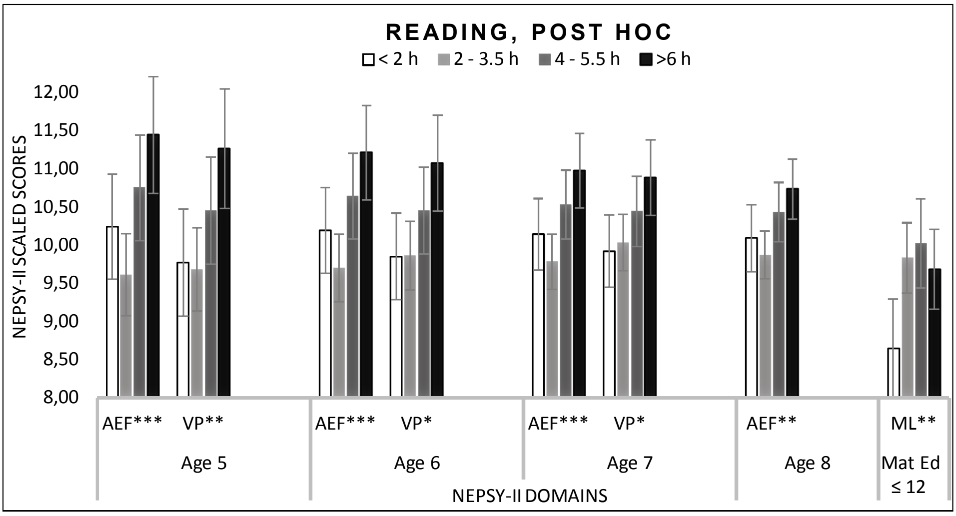

Figure 4 Relationship between weekly time spent reading and neurocognitive functioning, separately for all significant age groups and for the significant maternal education group in the post hoc analyses (age groups 5–8 and maternal education level of maximum of 12 years of education, for specific subtests). Estimated marginal means are presented for each domain. Error bars denote ±2 SE (95% confidence interval). AEF = Attention/Executive Functioning, ML = Memory/Learning, VP = Visuospatial Processing.
*** = *p* < .001, ** = *p* < .01, * = *p* < .05

4.3 RELATIONSHIPS OF AGE AND NEUROCOGNITION TO EMOTION RECOGNITION

Age was significantly related to the raw scores of the Affect Recognition subtest in Finnish 3–6-year-old children. When comparing consecutive age groups, the increase in performance was significant. The trend analysis showed a larger increase in performance on the subtest among the younger age groups, with a mild deceleration between ages 5 and 6. In Table 9, the mean scores, standard deviations, Tukey-corrected post hoc comparisons, and trend analyses are presented.

Correlations between scaled scores of the Affect Recognition subtest and the domains Attention/Executive Functioning, Language, Memory/Learning, Sensorimotor, and Visuospatial Processing domains, and the Theory of Mind subtest ranged between .20 and .52 and were significant ($p < .001$) for all included variables. The regression analyses showed significant relations between the Affect Recognition subtest and the Attention/Executive Functioning ($\beta = .13$, $t = 2.35$, $p = .019$) and Language ($\beta = .14$, $t = 2.35$, $p = .019$) domains, and the Theory of Mind subtest ($\beta = .11$, $t = 2.09$, $p = .037$). Further regression analyses with backward elimination were run, until no unsignificant results remained. In the commonality analysis, run with the Attention/Executive Functioning, Language, Sensorimotor, and Theory of Mind variables, positive and significant effects on the Affect Recognition subtest were found for all variables (ps = .001–.046). The Language domain showed the largest influence on emotion recognition (65.4% of R^2), and 18.2% of the total explained variance was ascribed to language functions. Attention/Executive Functioning accounted for 45.6% of R^2, Theory of Mind for 39.1% of R^2, and Sensorimotor for 33.6% of R^2.

Table 9 *Mean and Standard Deviation for the Four Age Groups; Mean Difference Among Consecutive Age Groups (Tukey Corrected); and Linear, Quadratic, and Cubic Trends for the One-Way ANOVA with the Affect Recognition Subtest [F (3, 366) = 281.80, p < .001, η_p^2 = .70].*

	Age Groups			
	3	4	5	6
M	6.82	10.47	16.01	17.74
SD	2.94	2.99	3.13	2.31

			95% Confidence Interval	
Age Groups	Mean Difference	*p*	Lower Bound	Upper Bound
3 vs 4	-3.65	< .001	-4.74	-2.56
4 vs 5	-5.54	< .001	-6.62	-4.46
5 vs 6	-1.73	< .001	-2.82	-0.64
3 vs 5	-9.20	< .001	-10.27	-8.12
3 vs 6	-10.93	< .001	-12.03	-9.82
4 vs 6	-7.27	< .001	-8.38	-6.17

	Sum of Squares	*df*	*F*	*p*
Linear	6,671.44	1	809.38	< .001
Quadratic	85.25	1	10.34	.001
Cubic	152.87	1	18,546	< .001

5 DISCUSSION

Neurocognitive functions—attention/executive functions, language, memory, social perception, sensorimotor functions, and visuospatial processing—develop with increasing age (e.g., Korkman et al., 2013; Rosselli et al., 2010; Waber et al., 2007). When a child suffers from a developmental or acquired brain disorder, difficulties on neurocognitive tasks may appear (e.g., Barron-Linnankoski et al., 2015; Koivisto et al., 2015; Reinvall et al., 2013). Not only children experiencing neurocognitive or behavioral difficulties can show lower performance on neurocognitive tasks. Typically developing children also often perform in the lower range of the scores on one or a few subtests (Brooks, Sherman, & Iverson, 2010; Wechsler, 2010). Such variation in performance may relate to innate genetic, but also to different or social environmental factors, as neurocognitive skills are related to the environment of the child (e.g., Anders et al., 2012; Ardila & Rosselli, 1994; Burger, 2010; Byrd et al., 2008; Davis-Kean, 2005; Downer & Pianta, 2006; Korkman et al., 2001; McLoyd, 1998; Olson & Jacobson, 2015; Pinto et al., 2013; Sarsour et al., 2011; Tong et al., 2007). The aim of the present thesis was to investigate variables relating to variation in neurocognitive performance in three samples of typically developing 3–15-year-old children. The relationship between neurocognitive performance and cultures (Study I), habits of media use (Study II), and emotion recognition (Study III) were investigated.

On a general level, all investigated factors proved to significantly relate to children's neurocognitive performance. Cultural differences among Finnish, Italian, and U.S. children were more pronounced in the younger age groups when compared to the older and more significant for some neurocognitive functions than others. Computer use and reading were positively related to some neurocognitive functions in U.S. children, whereas TV watching had a negative relationship with children's neurocognitive performance. The performance increased with age on all assessed NEPSY-II subtests, and more specifically, the ability to recognize emotional expressions showed a specific pattern of increase in young Finnish children. Emotion recognition ability also proved to be significantly related to other neurocognitive functions, of which the most significant relating factors were language, attention/executive functions, and theory of mind. In all, the present study shows that different aspects of the child's background and environment may explain some of the variance in neurocognitive performance. In the following sections, the findings are discussed. Studies I–III are discussed separately, followed by limitations of the studies and a general discussion with implications.

5.1 DIFFERENCES BETWEEN THREE COUNTRIES

The fairly new but growing field of cross-cultural neuropsychology has established that performance on a number of different cognitive tasks differs among different cultural or ethnic groups (e.g., Brickman et al., 2006; Fernandez & Marcopulos, 2008; Manly et al., 1998; Rosselli & Ardila, 2003). Such differences in adults have been attributed to differences in a variety of background factors and methodologies used (e.g., Brickman et al., 2006; Ojeda et al., 2014; Olson & Jacobson, 2015). Pediatric cross-cultural studies are still generally few (Byrd et al., 2008), and information is especially limited in neurocognitive tasks assessed between Western children with a broad age range. Study I compared neurocognitive performance on NEPSY-II among children from Finland, Italy, and the United States. As in previous studies with children from different language and cultural groups, age was significantly related to performance on all tasks (e.g., Korkman et al., 2001; Korkman et al., 2013; Rosselli et al., 2010; Waber et al., 2007). However, performance differences were assessed for each age group of the 3–15 year olds, and significant differences on most assessed neurocognitive abilities were found —although these did not emerge in all age groups and were not always consistent.

More specifically, on some subtests, differences among the countries were consistently found in a majority of the age groups. For example, Italians outperformed the Finnish and U.S. children for several age groups on the Affect Recognition subtest. Although the performance on all subtests increased with age in all countries, differences in the developmental curves emerged. For instance, Finnish children outperformed U.S. children in most of the younger age groups on the Comprehension of Instructions subtest, while the developmental curve of the Italian children differed between ages 4 and 6. The performance of the Italian children first decelerated mildly and then spurted, when compared to the performance by the Finnish children. On the Phonological Processing subtest from the Language domain, the spurt of the Finnish children differed from the spurt of the other children: The subtest was more difficult for Finnish children compared to the others when looking at the younger age groups (5–8 years), whereas it was more difficult for U.S. children compared to the others when looking at the middle age groups (8–12 years). In the older age groups, no significant differences emerged. Other examples include the Design Copying subtest, where U.S. children were generally outperformed. Other differences in performances and developmental curves are seen to some extent for most subtests (see Table 7 and the Figures in the original publication, see Study I). However, the Memory for Faces subtests showed few significant pairwise comparisons in general. Still, while significant differences were found for most subtests among at least two of the countries and for some age groups, they did not always appear for all age groups or among all three countries.

The fact that the differences evened out during preadolescence and adolescence for most subtests shows that assessing children of these age groups in multicultural settings with NEPSY-II could provide more robust results than assessing younger children. On a theoretical level, this finding implies that while there seems to be some developmental curve differences among different cultural groups on different measures, these seem to become more even during adolescence, perhaps due to similarities in education. This is in line with the review by Bird and colleagues (2008), who suggested that the developmental pattern in child neurocognitive performance may be non-linear. However, this result may be seen as contradictory when compared to the adult cross-cultural neuropsychological field, which has reported differences among a number of cultural groups on various tasks (e.g., Boone et al., 2007; Brickman et al., 2006; Manly et al., 1998). This discrepancy may be due to background, culture-specific, educational, and environmental factors influencing cultural differences in various ways in children and adults. Further, while some previous studies have reported significant cross-cultural performance differences on various tasks in children from a narrower age range (e.g., Cheie et al., 2015; Garratt & Kelly, 2008; Restrepo et al., 2006), it is possible that such differences would not emerge in another age group or when looking closely at each age group separately. Thus, the present finding suggests that including broad age ranges in studies, while simultaneously looking closely at performance differences for individual age groups may provide more specific information regarding actual cultural differences.

As suggested in previous studies (e.g., Brickman et al., 2006; Olson & Jacobson, 2015), the present significant differences may be ascribed to various factors—educational, cultural, background, language, and assessment factors all influence the child and may be the cause for neurocognitive performance differences. For instance, school start may influence some neurocognitive functions (e.g., Bentin, Hammer, & Cahan, 1991; Hughes et al., 2014; Korkman, Barron-Linnankoski, & Lahti-Nuuttila, 1999; Morrison, Smith, & Dow-Ehrensberger, 1995). Italian and U.S. children generally begin formal education earlier than Finnish children do. Performance on the Phonological Processing subtest seemed related to school start age for the three countries in Study I, with an increase in performance when children started school in the respective country. Also, theory of mind performance has been suggested to relate to the beginning of school (Hughes et al., 2014), which could explain that significant differences in Study I among the countries were no longer evident after children from all three countries were in school. Thus, it is possible that school start age and other educational variables, such as quality and quantity of day care and school (e.g., Montie, Xiang, & Schweinhart, 2006), may explain some of the differences found in Study I.

It is possible that different cultural factors explain the findings. These may be structural and organizational (such as politics or related to health or social care systems) but may also relate to differences in families and their communication and collaborations, as has been shown in relation to social perception and theory of mind ability (Gavrilov, Rotem, Ofek, & Geva, 2012; Hughes et al., 2017; for a summary, see Shahaeian, Nielsen, Peterson, & Slaughter, 2014). Further investigation of different family variables influencing neurocognitive performance will, thus, be an important goal for future studies.

For most NEPSY-II subtests, cross-cultural differences emerged in Study I. However, the two Memory for Faces subtests were mostly non-significantly related to the assessed countries. This finding was in line with previous studies with bilinguals and children with ASD from different countries yielding non-significant findings when comparing the groups on the Memory for Faces subtest (Elsheikh et al., 2016; Garratt & Kelly, 2008). In the present study, there were no significant cross-cultural differences in performance on face memory after age 8, thus confirming previous studies indicating that this is a relatively early developing skill (Crookes & McKone, 2009). The Memory for Faces subtest, thus, seems to be fairly robust, at least when comparing three Western countries.

In all, the results of Study I confirmed previous studies when showing pediatric cross-cultural differences in neurocognitive performance, while simultaneously showing that such differences do not necessarily occur for all age groups among 3–15 year olds, especially not in the older age range.

5.2 RELATIONSHIP WITH MEDIA USE

It has long been evident that the home environment of children relates to their academic and cognitive performance (e.g., Anders et al., 2012; Ardila & Rosselli, 1994; Burger, 2010; Davis-Kean, 2005; Downer & Pianta, 2006; Korkman et al., 2001; McLoyd, 1998; Olson & Jacobson, 2015; Pinto et al., 2013; Sarsour et al., 2011; Tong et al., 2007). Being a growing part of the child's home environment and daily life, media use has intrigued researchers for decades (e.g., Foster & Watkins, 2010; Schmidt & Vandewater, 2008). However, the possible effects of media use on children's performance remain unclear, as studies have shown both positive, negative, and no significant relationships between time spent using different media and cognitive performance. This perhaps at least partly depends on different methodologies used and different media use variables and cognitive measures studied. In contrast, previous studies have uniformly reported positive relationships between time spent reading and cognition. Still, children use an increasing amount of electronic media (Rideout et al., 2010), and hence, attempts at investigating relationships between media use and neurocognitive performance in children are important. In Study II, we found significant effects of time spent watching TV, using computer, and reading on U.S. children's neurocognitive performance. However, these effects differed. TV watching was negatively related to all neurocognitive functions, whereas computer use was positively related to language, memory, and social perception performance. Reading was positively related to attentional and visuospatial performance in younger children and to memory performance when maternal education was lower.

TV watching showing negative relationships with all neurocognitive domains when reading, computer use, and background factors were taken into account is in line with previous studies showing negative relationships among TV watching and attentional functions (Acevedo-Polakovich et al., 2006; Levine & Waite, 2000; Lillard & Peterson, 2011; Nikkelen et al., 2014; Swing et al., 2010; Séguin

& Klimek, 2016; Verburgh et al., 2016), language skills (Chonchaiya & Pruksananonda, 2008), and theory of mind (Nathanson et al., 2013). However, other studies have found no significant or some positive results of TV watching and neurocognitive abilities (e.g., Dworak et al., 2007; Linebarger & Walker, 2005; Mar, Tackett, & Moore, 2010; Verburgh et al., 2016). These differing results may be due to different methodologies used and the influence of other background factors (e.g., Ferguson et al., 2011; Foster & Watkins, 2010). Further, the fact that maternal education showed larger effect sizes in the present study than TV watching may indicate that while TV watching seems to account for some of the variance of the tasks, other factors might also explain the variance of neurocognitive performance.

Previous studies have indicated that general use of computers or use of the internet is related to better academic performance and some cognitive functions (e.g., Borzekowski & Robinson, 2005; Jackson et al., 2006; Subrahmanyam, Greenfield, Kraut, & Gross, 2001). The present study thus confirmed such findings. General use of computers—time spent using the computer for a variety of activities, including searching the internet, playing games, or homework—seems to be positively related to a variety of cognitive functions. However, negative relationships between different computer use and inhibition, but no significant relationships with other neurocognitive abilities including attention, have recently been reported in 8–12 year olds (Verburgh et al., 2016). In Study II, computer use was not significantly related to the NEPSY-II domain Attention and Executive Functioning. This domain included measures of inhibition, in addition to several other tasks of attention and executive functioning. Because we did not investigate computer use in relation to individual subtests, it is possible that results similar to the ones reported by Verburgh and colleagues (2016) might have emerged with the present data. Further, it is also possible that specific types of computer use might have yielded different relations to neurocognition.

The present findings indicate that language, memory, and social perception functions might be trained by computer use. This is not surprising, because it can be assumed that children need to read and remember, for example, homework, game instructions, or websites when using the computer. Also, children commonly use computers for social media (Rideout et al., 2010) which might train social perception abilities.

It was not surprising that reading proved to be positively related to neurocognitive functions because no previous negative effects of reading were found. Some previous studies indicated relationships between reading or home library size and school achievement (Evans et al., 2014; Mol & Bus, 2011; Rowe, 1991). In the present study, the results suggested that reading relates to attentional and visuospatial functions in younger children and to memory functions when the mothers are educated for less than 12 years. Thus, the present findings broaden previous knowledge and indicate that in young beginning readers, attentional and visuospatial skills may be trained by more time spent reading. This might be related to children reading picture books or attentively focusing on letter shapes, for example. Reading seems especially important for neurocognitive functions during the vigorous developmental time in early elementary school years (e.g., Korkman et al., 2013). Still, it is possible that reading in older children has a positive effect on other variables not measured here. Further, it seems that memory performance could be enhanced by more time spent reading if maternal education is 12 years or less. Thus, as memory functions relate to academic achievement (Bull, Espy, & Wiebe, 2008; Titz & Karbach, 2014), improving memory functions by reading could lead to better educational attainment as well.

In summary, time spent using media proved to significantly relate to neurocognitive performance and when maternal education, sex, and other media variables were taken into account. Whereas daily TV watching was negatively related to all assessed NEPSY-II domains, weekly computer use was positively related to some functions. Weekly reading was positively related to neurocognition in younger children and when maternal education was lower.

5.3 RELATIONSHIP WITH EMOTION RECOGNITION

Emotion recognition ability—the ability to understand and match emotional expressions—is an important part of social functioning, and it has recently been related to a number of different neuropsychiatric disorders or deficits (e.g., Chronaki et al., 2015; Corcoran et al., 2015; Sivaratnam et al., 2015). The ability to match emotional expressions non-verbally seems to develop during the preschool years (De Sonneville et al., 2002). Study III aimed to investigate emotion recognition in preschool-aged Finnish children to provide more specific information about the developmental sequence of this ability during this age period. Another aim was to explore the relationship between emotion recognition and other neurocognitive abilities because information on relating variables may help in understanding emotion recognition development and deficits relating to this ability.

Study III found that the ability to match emotional expressions improved with age in 3–6-year olds but that this development was uneven, being steeper in the younger age groups and decelerating after age 5. Thus, the ability to match basic emotions non-verbally seems to develop fairly early in childhood. It is possible and likely that other, more complex emotion recognition abilities, such as naming emotions or recognizing subtle changes in emotional expressions, continue to develop into later childhood and adolescence. Such development has been previously reported (e.g., Thomas, De Bellis, Graham, & LaBar, 2007; Vicari et al., 2000; Widen & Russell, 2003; Widen & Russell, 2010).

Emotion recognition proved to correlate significantly but moderately with all assessed domain variables, thus indicating that there are significant relationships between recognition of emotions and other neurocognitive functions. In further analyses, the Affect Recognition subtest proved to be related to language, attention/executive functioning, theory of mind, and sensorimotor functions. Of these, language functions explained the largest part of the variance, thus not confirming other studies that suggest that non-verbally assessed emotion recognition should rely on visual rather than on linguistic functions (Herba et al., 2006; Vicari et al., 2000). This finding implies that the ability to label emotions may underlie the ability to accurately match them. In fact, a recent study reported that in 9–18-year-old children with Down syndrome and nonspecific intellectual disabilities, as well as in 3–6-year-old typically developing children, emotion recognition accuracy increased when, before matching, the emotions were labeled by the test leader (Cebula et al., 2017). Further, an early study reported significant relationships between receptive language skills and matching of emotions (Smith & Walden, 1998). Recently, significant positive correlations to emotion recognition have been reported for both language production and comprehension (Cebula et al., 2017). In Study III, a combined variable of both receptive and expressive language skills was used. Thus, it seems that different language abilities are related to preschoolers' non-verbal emotion recognition performances.

The present relationship between language and emotion recognition links to and confirms the research field reporting relationships among linguistic functions and different social or emotion awareness skills in both typically developing children and different clinical groups across childhood (e.g., Beck, Kumschick, Eid, & Klann-Delius, 2012; Mancini, Agnoli, Trombini, Baldaro, & Surcinelli, 2013; Martin, Williamson, Kurtz-Nelson, & Boekamp, 2015; Stanton-Chapman, Justice, Skibbe, & Grant, 2007). The present finding also relates to studies showing relationships between theory of mind ability and language (e.g., Milligan, Astington, & Dack, 2007; Shahaeian, Nielsen, Peterson, Aboutalebi et al., 2014). Further, there are also links to previous findings reporting significant relationships between language abilities and children's social skills and psychosocial well-being (Andrés-Roqueta, Adrian, Clemente, & Villanueva, 2016; Aro, Eklund, Nurmi, & Poikkeus, 2012; Beitchman et al., 1996). Thus, it seems that language functions may broadly be related to different aspects of social competence. It is still possible, however, that broad measures of language (i.e., receptive and expressive skills, combined) may be less relevant for emotion matching in older children. Such a theory could explain the discrepancy between the present findings and a previous study, which reported no significant relationships between receptive language and emotion matching across childhood (Herba et al., 2006).

Regarding the other neurocognitive functions, the Theory of Mind subtest and Attention/Executive Functioning domain were also significantly related to the Affect Recognition subtest, which was in line with previous studies (Buitelaar & van der Wees, 1997; Mathersul et al., 2009; Mier et al., 2010). Thus, mentalizing as well as attention and impulse control were related to emotion recognition. The Sensorimotor domain explained some of the variance of the Affect Recognition subtest, but this effect was small compared to the previously mentioned functions. Moreover, Visuospatial Processing and Memory/Learning were not significantly related to the subtest.

This was knowingly the first study to more thoroughly investigate the development of emotion recognition in preschool-aged children, presenting increases and decelerations in the developmental curve for this ability. Further, emotion recognition ability was significantly related to neurocognitive functions, and especially to language functions.

5.4 LIMITATION OF THE STUDIES

Studies I–III have several strengths, including a large number of participants, a broad age range, and neurocognitive functions being comprehensively assessed with an internationally well-known test. However, some limitations of the studies should also be taken into account. For some of the significant findings in Study I, effect sizes were fairly small. When looking at the results of the ANOVA (Table 6), only the Design Copying subtest showed a large effect size when comparing the three countries. Age was the factor most significantly related to the neurocognitive variables, partly due to the age range being broad (3–15 years). Thus, in the analysis, some effects between the countries may have been restrained by the age effect. In the pairwise comparisons, the sizes of the effects were mostly medium or large. Still, due to some of the effects in the ANOVA and pairwise comparisons (Tables 6 and 7) being fairly small—especially for the subtests Block Construction, Comprehension of Instructions, and Memory for Faces—the practical significance of the findings may be discussed. Some of the significant differences reported in Study I might be more evident on a practical level than other differences: As indicated by the effect sizes, medium and strong pairwise comparison differences emerged for especially the subetsts Design Copying and Geometric Puzzles, but also for the subtests Affect Recognition and Phonological Processing. Generally, however, even if the children in one country would perform less well on a specific task as compared to children in other countries, difficulties in daily life should not emerge as a result of the differences found in Study I, because the samples were from normative data of typically developing children.

Differences in the samples might also have affected the results of Study I. There were some differences in the data collection procedures among the three countries. One is the age of the participants. While the Finnish children were assessed during the months around their birthday, the Italian and U.S. children were assessed throughout the year between birthdays. Thus, the average age of the Finnish children was lower than the average age of the children from the other countries. It is impossible to know how this and other differences regarding the recruitment of children to the standardization in the three countries (see section 3.1. Participants and Procedures) might have affected the results, but it is important to note that such differences were present in the data. For instance, including parental education level in the analyses, thus investigating the relationship between parental education level and the age-country-relationships, could have provided useful information for interpretation of the scores. Furthermore, pediatric neuropsychological assessments are interactive situations. Therefore, even if the examiners were trained in administration and scoring of NEPSY-II, also some tester-specific differences may have occurred, which might have influenced the results—not only in Study I, but also in Studies II and III.

In Study II, a large group of children participating in the NEPSY-II standardization were not included in the study, as they had no available media use information. Their attrition (49%) might be due to the home environment questionnaire being fairly extensive. When compared to the dropout group, significantly more girls and children with higher parental education level participated in Study II. The participant group scored significantly higher on the Social Perception and Visuospatial Processing domains than the drop out group. Thus, it is possible that the findings would have been somewhat different, had media information been available for the whole group. Further, as with other information collected on a questionnaire, there is a margin of error regarding the information the parents provided. Still, parental questionnaires are a common research method when collecting media use information. Further, the effects of the significant relationships among media variables and neurocognitive functions were fairly small. Thus, it should be noted that some of the variance may be explained by the media variables, but that other factors in the background and environment of the child might also explain some of the performance. For future research, it would be of use for families, educators, and clinical practice to investigate further the relationship between media use and neurocognition by looking at what children watch on TV, do on the computer, or which material they read.

In Study III, some children—mostly 3–4 year olds–had missing data on the Statue (7.8%) and Word Generation subtests (8.4%). These values were replaced with EM estimation, but these may not completely reflect the reality. These subtests were included in the Language and Attention/Executive Functioning domains. As these domains were significantly related to the Affect Recognition subtest, one should be aware of the possibility that the scores could have differed to some extent if there had been less missing data.

The reliability of the Affect Recognition subtest also suggests some limitations. The overall reliability estimate for the subtest was 0.94 (Chronbach's α) in the Finnish standardization data (Korkman, et al., 2008b), but when looking more closely at the reliability of the specific age groups, the 3, 4, 5, and 6 year olds' α coefficients were 0.67, 0.69, 0.64., and 0.47, respectively (Korkman, et al., 2008b). The reliability estimates for the other subtests included in the domains used in Study III varied for different age groups, but ranged between 0.31 and 0.94 (Korkman, et al., 2008b). However, only few reliability coefficients for the included subtests per age groups were < .60, and half of them were > .80 (Korkman, et al., 2008b), thus indicating fairly good reliability of the subtests for the age groups. Still, the few lower reliability estimates might have lowered some of the differences found between the Affect Recognition and the NEPSY-II domains. In other words, some of the significant findings reported in the present study might have been stronger if the reliability of the measures had been more robust for specific age groups and subtests.

5.5 GENERAL DISCUSSION AND PRACTICAL IMPLICATIONS

The present thesis investigated variation in neurocognitive performance, as assessed with NEPSY-II, in three samples of typically developing 3–15-year-old children. The findings add novel information to the neuropsychological research fields of cultural-, media-, and social-functioning studies. The present thesis also relates to previous studies, such as age, sex, and parental education relating to neurocognitive performance (e.g., Anders et al., 2012; Ardila & Rosselli, 1994; Burger, 2010; Davis-Kean, 2005; Downer & Pianta, 2006; Korkman et al., 2001; McLoyd, 1998; Olson & Jacobson, 2015; Pinto et al., 2013; Sarsour et al., 2011; Tong et al., 2007). However, this is knowingly the first study to investigate the relationship of the specific variables of culture, media use, and emotion recognition to neurocognitive performance assessed comprehensively with an international gold standard, in a broad age range of typically developing children.

On a general level, the thesis adds information to the research investigating NEPSY-II performance in both typically developing children and in different clinical groups (e.g., Barron-Linnankoski et al., 2015; Haavisto et al., 2012; Karlsson et al., 2015; Kinnunen et al., 2013; Klenberg et al., 2015; Koivisto et al., 2015; Korkman et al., 2013; Reinvall et al., 2013). Together, the thesis and previous studies add to the clinical utility of the assessment material. The results of the present thesis suggest that differences may occur on similar tasks depending on the age of the child as well as in different Western cultures and depending on time spent using different media. The ability to recognize facial expressions of emotion proved to be related to different neurocognitive abilities—especially language. These findings generally imply that the age and cultural background of the child, habits in the home, and other neurocognitive abilities may affect neurocognitive performance and should be considered in clinical neuropsychological assessments. Thus, Studies I–III have some specific implications for educators, families, and clinical practice as well as for future research.

Implications for educators involve awareness of the present findings when planning education in preschool, kindergarten, and schools, and when organizing intervention and special needs education for children who struggle in school. Based on Study I, educators should know that differences between children from various backgrounds and cultures might not only be expressed as differences in cultural traditions and heritage, but that differences can be observed also at the level of neurocognitive task performance. Study II indicates that continuously encouraging reading and the use of computers for studies is warranted for. The findings of Study III also have some implications for families and kindergarten educational settings. As emotion recognition proved to partly be related to different neurocognitive functions in preschoolers, social competence training and interventions should be focused not only on social skills, but more broadly on several neurocognitive areas. Also, such social interventions should be directed to young children.

Pediatric neuropsychologists are often faced with the challenge of assessing children from a different cultural group than the majority culture of the population. Although there are now some ethical instructions and directions for assessing children from different cultures (e.g., American Psychological Association, 2003; Board of Directors American Academy of Clinical Neuropsychology, 2007), and several handbooks have been published (Ferraro, 2016; Fletcher-Janzen et al., 2000; Rhodes et al., 2005; Uzzell et al., 2007) and instructive webinars are being held (Castro & Judd, 2015; Salinas & Vegas, 2016), many obstacles and difficulties still emerge. One such difficulty relates to the assessment material used. Neuropsychologists should always use materials developed and normed in the cultural group of the individual (for discussions, see Brickman et al., 2006; Manly, 2008b; Olson & Jacobson, 2015; Veliu & Leathem, 2016). However, if this is not possible, the best available materials should be used (Rivera Mindt et al., 2010). In such cases, it is important to know in general which neurocognitive tasks are sensitive to cultures and which are more robust. Based on the present and previous studies, it is almost impossible to draw conclusions that would be generalizable across different countries, languages, and intracountry groups. Thus, caution should always be used when applying the present results on assessments of children from other cultural groups than assessed here. Still, some general guidelines can be drawn. Based on the present study, most NEPSY-II tasks are more culturally robust in the older age ranges—often from age 11 or 12. However, some tasks seem to be robust from an earlier age. These are Memory for Faces Immediate (age 9) and Delayed (age 6) and Theory of Mind (age 7). Other subtests—Design Copying and Geometric Puzzles—showed significant differences in older age groups and may be considered more culturally sensitive. The effect sizes presented in Table 7 indicate specifically the strength of the differences among the countries for separate age groups ($d = 0.3$ = one NEPSY-II scaled score; $d = 0.7$ = two NEPSY-II scaled scores).

One practical clinical implication for Finnish clinicians involves the assessment of specific minority groups in Finland. For instance, children from English-speaking families living in Finland may be assessed with the U.S. version of NEPSY-II. In addition, for the Swedish-speaking minority in Finland, the Swedish version of NEPSY-II may be used. The Swedish NEPSY-II utilizes U.S. normative data, the applicability of which was confirmed with a Swedish sample (Korkman, et al., 2011b). Although the specific clinical implications of the presently reported differences in normative data between the Finnish and U.S. samples on several of the tasks still need to be confirmed with clinical samples, practitioners may wish to take both norms into account when assessing English- or Swedish-speaking children in Finland. Thus, the individual child's clinical performance would be compared to both the language group of the child (English/Swedish) and to the country norms (Finnish). Neither normative data may be completely correct for these groups, but both may be applicable to some extent and may add perspectives to the interpretation of the individual child's performance on tasks. In written reports, clinicians should always state which assessment version and normative data were used. Table 7 provides a specific overview of the comparability of different NEPSY-II subtests. In addition to considering the effect sizes of the comparisons for each age group (Table 7), clinicians performing assessments with Swedish- or English-speaking children in Finland are also, before comparison of scores, advised to consider the adjustments in some of the subtests made before comparison in Study I. Also, because all existing NEPSY-II subtests were not included in Study I, before comparing norms for specific subtests, clinicians are referred to Table 2 for information about similarities and differences among the country versions of NEPSY-II.

The results from Studies II and III may be used in clinical settings as well as in families and educational settings. The findings of Study II, conducted with a U.S. sample, imply that time spent reading is related to attentional and visuospatial performance in younger children, as well as to memory in children with a lower level of maternal education (less than 12 years). Thus, children showing deficits in neurocognitive tasks should be encouraged to increase hours of reading per week. It is possible that at least memory functions may be improved when children with lower-educated parents are encouraged to read more. Children showing deficits in tasks of language, memory, or social perception should be encouraged to increase the weekly time spent on computers. However, the only assessed medium to be related to all included neurocognitive domains was television. As this relationship was negative, it may be suggested to decrease the daily time children spend watching TV. While these relationships were investigated in a U.S. sample, one might expect that countries with similar use of media (such as other Western countries, including Finland) would show relationships between media use and neurocognition of at least the same direction as the present findings.

It should be noted that the direction of the significant relationships between media use and neurocognition cannot for certainty be stated here because of the design of Study II being cross-sectional. It is possible that children with higher scores on neurocognitive tasks use the computer and read more as well as watch TV less. There has, however, been some indication of bidirectional relationships between media use and some cognitive functions (Acevedo-Polakovich et al., 2006). Hofferth and Moon (2012) showed that an increase in media use was related to an increase in some cognitive achievement and to a decrease in other tasks, when measured in 2003 and 2008. They suggested that this methodology indicated causality of the associations (Hofferth & Moon, 2012). Therefore, some causal relationships between media use and neurocognitive performance may exist. Reciprocal relationships between media use and neurocognition might also be present. For instance, children with certain neurocognitive strengths may read more than others; more reading could lead to strengthening of certain neurocognitive abilities; certain neurocognitive strengths could lead to an interest in reading, and thus to more reading.

When assessing children with deficits in emotion recognition ability, as shown with the Finnish sample in Study III, performance in tasks of attention and executive functions, language, and theory of mind should be considered. The significant relationship between these functions and emotion recognition imply that in case of impaired affect recognition, other neurocognitive functions may also be impaired or even to some extent explain the emotion recognition deficit. These findings may have implications for the daily interaction of children in the home and with peers. Children with better emotion recognition skills may also have other strong neurocognitive skills and may thus have an advantage in social situations compared to children with difficulties in one or several neurocognitive functions. Language functions, which are also important for social competence (e.g., Beck et al., 2012; Stanton-Chapman et al., 2007), may be an especially sensitive indicator, as this domain showed the strongest relationships with the emotion recognition ability. Thus, social competence may be affected when difficulties occur both in emotion recognition and language abilities.

The present findings also have theoretical implications. Relationships between background and environmental variables and clinically assessed neurocognition may form a basis for future studies on neural underpinnings of such relationships. The findings in Studies I–III clearly show that neurocognitive functions develop in close relationships with the environment, background, and other neurocognitivecognitive characteristics of the child. However, whereas we showed that cultures, media use, age, and other neurocognitive functions are related to performance, these reported factors do not explain all of the variance in performance. Thus, future studies should focus on exploring and investigating other possible explanatory factors. Parental education level is one, which has traditionally shown to influence a number of cognitive and educational factors (e.g., Letts et al., 2013; McLoyd, 1998; Sarsour et al., 2011). Investigating other factors that possibly influence pediatric cultural and media use effects on neurocognition will be an important area for future research.

Combining the factors in the present study could provide more specific information on the relationships outlined here. For instance, there is indication of the relationship between media use and cognitive performance being mediated by other background factors, such as sex and ethnicity (Hofferth, 2010; Hofferth & Moon, 2012). Other important future research areas include different forms of media multitasking in children—this research line so far seemingly shows significant negative relations to cognition in both adolescents (M. S. Cain et al., 2016; Moisala et al., 2016) and adults (e.g. Cardoso-Leite et al., 2016; Ophir et al., 2009). For future studies, it will be important to know the effects of use of traditional media devices on cognition when combining these devices with newer forms of media use, such as tablet computers or smart phones.

5.6 CONCLUSIONS

Neurocognitive functions, such as attention/executive functions, language, memory/learning, sensorimotor functions, social perception, and visuospatial processing, develop with the child's age (Korkman et al., 2013; Rosselli et al., 2010; Waber et al., 2007). This development reflects brain maturity (e.g., Casey et al., 2000; Casey et al., 2005; Fuster, 2002), but also relates to the background and environment, not the least socioeconomic factors, of the child (e.g., Hackman & Farah, 2009; Letts et al., 2013; McLoyd, 1998; Montie et al., 2006; Sarsour et al., 2011). The present thesis suggests that culture, media use habits, as well as age and other neurocognitive functions also relate to performance on neurocognitive tasks in 3–15-year-old children. In the three included studies, standardization data of the child neuropsychological assessment NEPSY-II, consisting of a total of 2,745 children from three countries, was utilized.

Cultural differences emerged for several age groups on a number of subtests from NEPSY-II when assessed in 3–15 year olds from Finland, Italy, and the United States. The findings imply that cross-cultural differences may emerge between different normative data, even when assessed in three Western countries. These differences, however, did not emerge for all age groups and not always among all three countries. Thus, there were also differences in the developmental sequences in the three countries, even if performance on all subtests generally increased with age. For most subtests, differences among the countries were no longer significant in adolescence.

Time spent using media was also related to neurocognitive performance in U.S. 5–12 year olds. The effect differed among various media. Time spent watching TV was negatively related to all neurocognitive functions, while time spent using the computer was positively related to language, memory, and social perception performance. Time spent reading was positively related to attentional and visuospatial functions in younger children and to memory functions when maternal education was lower.

The ability to recognize and match facial expressions of emotions improved with age in Finnish children and showed a specific pattern of development in the preschool age range (3–6 years). This ability was also significantly related to other neurocognitive functions—especially language but also attention/executive functions, theory of mind, and sensorimotor functions.

To summarize, the present thesis explored the relationship between neurocognitive performance and different background and environmental variables and other neurocognitive characteristics. The studies suggest that neurocognitive performance develops with age but does not do so solely as a result of brain maturity but rather in close relationship with the environment, background, and other neurocognitive characteristics of the child. These results may explain some of the variations in neurocognitive performance that emerge in clinical assessments. As such, the findings should be taken into account clinically and may also imply some directions for families and educators. One specific implication involves clinical assessments of English- and Swedish-speaking children in Finland. Research-related implications include that the presented environmental variables should be further investigated individually and in combination with each other and other variables. Exploring specific functions and factors underlying the variables presented here will also be of importance. In all, some of the variation in neurocognitive performance may relate to culture, media use habits, age, and other related neurocognitive functions.

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