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General Introduction

Adolescence is the transitional phase of life between childhood and adulthood. The onset of adolescence is characterized by the start of pubertal maturation (Curtis, 2015; Kail & Cavanaugh, 2018). From that moment onwards, adolescents experience rapid physical growth and mature sexually (Dahl, 2004; Shirtcliff, Dahl & Pollak, 2009). Adolescents also gain many new experiences, such as in the transition from primary to secondary school (Baars, Nije Bijvank, Tonnaers & Jolles, 2016; Ruschoff, Kretschmer, Dijkstra & Veenstra, 2014). They develop new interests, gain new knowledge and develop new social relationships (Duan, Chou, Andreeva & Pentz, 2009; Jolles, 2016; Steinberg & Morris, 2001).

One of the most salient characterizations of adolescence is a steady increase in the ability to self-regulate; during adolescence individuals increasingly master the ability to control their thoughts, emotions and behavior in order to make them consistent with internal goals (Crone, 2009; Diamond, 2013). Together with this improving ability to self-regulate, associated brain networks continue to mature until at least early adulthood (Giedd, 2008; Lenroot & Giedd, 2010; Wierenga, Sexton, Laake, Giedd & Tamnes, 2017). Adolescence is thus a time of substantial changes in biological, psychological, and social functioning. It is notable that each adolescent experiences these individual changes and growth at different rates, with some persons moving through the adolescent phase quicker and more smoothly than others. Along the road to adulthood, each adolescent will experience some challenges in the psychosocial domain. Most of these challenges are a normal part of adolescence; they prepare the adolescent for adult life. A minority of the adolescents, however, experience more pronounced difficulties. Their academic performance may be compromised because of severe problems with planning their homework, learning for a test, or concentrating at school (e.g., Anderson, 2002; Gerst, Cirino, Fletcher & Yoshida, 2015). Psychological problems may also arise such as anti-social behavior and/or other problems in the social domain (Loeber & Farrington, 2012).

There are thus major individual differences in the developmental trajectory from childhood to adulthood. It was the aim of the studies in this thesis to investigate these individual differences. The focus was on the neuropsychological development of preadolescents and adolescents and determinants that may contribute to individual variations in learning performance.

On individual differences in development and their possible impact

Individual differences in school achievement are of major interest because of the possible impact for future functioning of that individual and the high costs for society. Higher educational levels are associated with higher incomes; highly educated individuals are also generally healthier, live healthier lives and live longer (e.g., Backlund, Sorlie & Johnson, 1999; Cutler & Lleras-Muney, 2006). Individuals that obtain lower educational levels, on the other hand, have fewer life prospects. This can be seen in lower initial and lifetime earnings and higher risks of unemployment: These individuals are more likely to receive government assistance (Laird, Kienzl, deBell & Chapman, 2007; Martin, Tobin & Sugai, 2003; Moore, Gleib, Driscoll, Zaslow & Redd, 2002). Lower education has also been linked to poor health, including poor mental health (Organization for Economic Co-operation and Development, i.e., OECD, 2011). Furthermore, young people who drop out of high school are unlikely to have the minimum skills necessary to function in today's increasingly complex society and technology-dependent workplace (OECD, 2017). Considering the consequences of lower education and the benefits of higher education, it is of quite some importance to evaluate *'what is needed to stimulate the development of adolescents to reach their full educational potential?'*

For good learning performance, students must acquire new knowledge. New knowledge can be presented both verbally and non-verbally. Students need to store this new knowledge into their memories to retrieve it at a later moment in time, on a shorter or longer term. This requires students to develop learning strategies and to adjust previous strategies that were effective in the past to become more effective in learning in the future. Here, numerous of neuropsychological abilities are involved, such as working memory, planning and organizing, mental flexibility, attentional functions, impulse regulation, and self-monitoring and self-regulation (Anderson, 2002; Diamond, 2013). These neuropsychological abilities enable adolescents to regulate their behavior, emotions and thoughts. They gradually develop over the course of adolescence into early adulthood (Anderson, 2002; Diamond, 2013). The development of these functions matches the stages of brain maturation. They involve the development of complex brain networks. These networks include the prefrontal cortex with connections to other cortical and subcortical areas (Giedd & Rapoport, 2010; Lenroot & Giedd, 2011; Leshem, 2016; Noble et al., 2015). In 2014, the OECD reported on the importance of these neuropsychological abilities to school achievement in their report *'Fostering and measuring skills'*. In this report, results of numerous scientific studies were presented which showed that these neuropsychological abilities predict a wide range of life outcomes. These

outcomes included educational achievement, and also labor market outcomes, health, and criminality (Kautz, Heckmanm Diris, Ter Weel & Borghans, 2014). Individual differences in the pace at which neuropsychological abilities improve may, therefore, contribute to individual variations in school achievement as well as on other life-outcomes such as anti-social behavior. Improving knowledge about determinants that contribute to individual differences in the pace at which neuropsychological abilities develop may offer relevant new insights into the underlying mechanisms involved in individual variations in school achievement.

On determinants of neuropsychological development

There are many possible determinants to individual differences in the development of neuropsychological abilities. In recent years, individual differences in the school achievements of children from lower and higher educated parents, and of boys and girls has received substantial research attention. Attention has especially been growing since the OECD published their report *'Lessons from PISA for the United States, Strong Performers and Successful Reformers in Education'* (Schleicher, 2011). In this report, they revealed that students of poorly educated parents are more likely to repeat grades than children of highly educated parents. Also, boys were more likely to repeat grades than girls. These trends have been reported in many industrialized countries (Schleicher, 2011). Differences between children of higher educated and lower educated parents have more recently also been reported in the Netherlands (The Inspection of Education, 2015). The inspection of education revealed in 2014-2015 that school achievement of children from lower educated parents was significantly lower than that of children from higher educated parents, even after controlling for IQ (The inspection of Education the Netherlands, 2015). Specifically, their findings showed that children of higher educated parents switch more often to higher educational tracks, and their school dropout rates were lower compared to children of lower educated parents. The most striking finding in this report was that the gap in educational achievement has increased over the past years. With respect to sex differences in academic achievement, the OECD (2015) reported in their report *'the ABC of Gender Equality in Education'* that boys are more likely to leave school early (often with no qualifications) and to have lower achievements in the academic domain than girls. Parental education and sex thus seem to be two valuable determinants to individual differences in school performance. They may, therefore, also be relevant determinants to individual differences in the neuropsychological development.

This thesis

The primary focus of this thesis was on learning performance of preadolescents and adolescents (7-19 years). This age-range was chosen because it is characterized by large developmental changes, including the switch from primary to secondary school and to higher education or to working-life. The main aim of this thesis was to study determinants to individual differences in learning processes and neuropsychological abilities of preadolescents and adolescents. The investigated processes and neuropsychological abilities are important for learning at school. Insight into determinants to individual differences in learning performance is needed to improve knowledge with respect to individual differences in school achievement. The aim is described in more detail after a short overview of the current literature on this topic.

BACKGROUND

Adolescence: The neuropsychological development

Adolescence is the transitional period between childhood and adulthood (Blakemore, Burnett & Dahl, 2010). This period is characterized by large behavioral, psychosocial and biological changes. With respect to the biological changes, neuroimaging studies have shown that both structural and functional brain maturation continues during adolescence (Giedd, 2008; Lenroot & Giedd, 2011; Giedd & Rapoport, 2010; Leshem, 2016; Noble et al., 2015; Wierenga et al., 2017). Maturation processes take place in many regions in the brain. Notable are the prefrontal brain areas and the many brain networks in which the prefrontal structures are involved. The changes in these networks continue to develop until at least well after the 20th year of life (e.g., Giedd, 2008; Lenroot & Giedd, 2011, Noble et al., 2015; Wierenga et al., 2017). These networks are the brain counterpart for the so-called *executive functions*. Executive functions are responsible for goal-directed and contextually appropriate behavior (Anderson, 2002; Diamond, 2013; Miller & Cohen, 2001). Core executive functions involve attentional functions, cognitive control, cognitive flexibility, and the processes involved in updating working memory and shifting. Other executive functions are self-monitoring, planning for the future as well as impulse control; which involves the initiation, planning and organization, and elaboration of possible consequences of actions, and decision making (see Box 1, see also Anderson, Anderson, Northam, Jacobs & Catroppa, 2001; Diamond, 2013). As the structures and functions of the prefrontal cortex continue to mature, adolescents acquire knowledge and

gather many experiences. As a result of that, they learn to manage emotions and behaviors. They also develop stronger reasoning skills, logical and moral thinking, and become more capable of abstract thinking and making rational judgements (Diamond, 2013; Jolles, 2016). The development of executive functions and self-regulatory skills allows them to become less vulnerable for sensation-seeking, risk-taking, peer influences and social acceptance (Albert, Chein & Steinberg, 2017).

The maturation of more basic brain structures and functions takes place at relatively early age. This applies to brain structures associated with basic motor and sensory functions, reward processing, and attention. The more complex functions and their associated brain networks, on the other hand, continue to mature until later ages up till late adolescence and emerging adulthood (e.g., Gogtay, 2004; Paus, 2005; Giedd, 2008; Wierenga et al., 2017). This applies to brain structures involved in executive functions and self-regulatory skills. Although the order in which many of the structural and functional changes of the brain manifest themselves appears to be universal, their timing and the speed of change vary among and even within individuals. Executive functions and self-regulatory skills, and also other neuropsychological abilities are important to school performance. Individual differences in the pace at which they develop may therefore contribute to individual variations in the school performances of adolescents. The studies in this thesis elaborate on several neuropsychological abilities, including executive functions and self-regulatory skills, and other processes involved in spatial and non-verbal learning.

Box 1. A definition of executive functioning

There are many definitions of the term *executive functions*. Most researchers use it as an umbrella term for various self-regulatory processes that are responsible for purposeful, goal-directed behavior. An authority in adolescent development is Adele Diamond. She has a clear description of what executive functions are. Her view is in line with the definition used in neuropsychological practices. In this discipline, abilities in emotional and behavioral control, and in reading the intentions of others belong to the executive functions. According to Diamond: ‘executive functions refer to a family of top down mental processes needed when you have to concentrate and pay attention, when going on automatic or relying on instinct or intuition would be ill advised, insufficient or impossible. Executive functions make possible mentally playing with ideas; taking the time to think before acting; meeting novel, unanticipated challenges; resisting temptations; and staying focused. Core EFs are inhibition (response inhibition, self-control, resisting temptations and resisting acting impulsively) and interference control (selective attention and cognitive inhibition), working memory, and cognitive flexibility (including creatively thinking “outside the box”, seeing anything from deferent perspectives, and quickly and flexibly adapting to changed circumstance)’ (Diamond, 2013).

Executive functions, non-verbal learning and spatial learning

Neuropsychological abilities that have been associated to school success in adolescence include the executive functions and self-regulatory skills (Best, Miller & Naglieri, 2011; Blair & Diamond, 2008; Demaray & Jenkins, 2011; Endedijk, Denessen & Hendriks, 2011; Latzman, Elkovitch, Young & Clark, 2010). In school, students need to neglect distracting information and sustain attention for prolonged periods of time. They need to be able to control impulsive behaviors in order to stay focused in class and to focus their attention to homework. In addition, students need good planning abilities and they have to prioritize between various subtasks for homework to be completed in time. It seems that well-developed executive functions and self-regulatory skills are advantageous to school performance. It is, therefore, relevant to examine whether individual differences in the developmental trajectories of these functions account for individual variations in school performance.

Besides executive functions, other processes are responsible for the adolescent's learning performance as well. A typical school task is when teachers give the explicit instruction to their students to learn new information because it will be tested afterwards. An example of when such an instruction is given, is when students need to learn words, conjugations of verbs, or other items such as 'the capitals of European countries'. Students need to transfer new knowledge into their memory in order to recall it later (Hampshire et al., 2016; Lezak, Howieson, Bigger & Tranel, 2012; Thomas & Rohwer, 1986). Individual differences in the ability to store information into memory and to recall it on the short term or on the longer term, may contribute to individual variations in school performance.

Notably, information is not always presented verbally at school and in daily life. Rather, it is also presented non-verbally. Learning non-verbal information involves identifying relationships, similarities and differences between shapes and patterns, recognizing visual sequences and relationships between objects, and remembering them. Non-verbal abilities are important for orienting in unfamiliar surroundings, to find the way in unfamiliar cities, and to learn subjects such as mathematics and geometrics (Halberda, Mazocco & Feigenson, 2008; Lezak et al., 2012). Next to individual differences in executive functions and in the ability to store and recall new information, the ability to process spatial information may also contribute to individual variation in school performance.

Both the characteristics of an individual (e.g. brain maturation, sex) and socio-environmental factors (e.g. socio-economic-status, parental education, culture and societal expectations of this period including the norms and values) may contribute to individual differences in the development of neuropsychological abilities. In this thesis, we focus on two

of these factors; sex and parental education. The following paragraph elaborates on these factors.

Determinants of the neuropsychological development

Boy-girl differences

The sex of an individual determines the adolescents' physical, sexual, psychological and social development. Sex hormones encountered during critical developmental periods (e.g., in utero, shortly after birth, during puberty) are often assumed to have permanent, maturational effects on brain development. The adolescent brain further matures by gonadal steroid hormones secreted during the period of puberty (see Schulz, Molenda-Figuira, and Sisk, 2010). During this period, there are clear differences in the pace at which brain maturation takes place between boys and girls (Hampshire et al., 2016; Juraska & Willing, 2017; Lenroot & Giedd, 2011; Miller & Halpern, 2014). Between 10 and 15 years of age, the maturation of networks involving the prefrontal brain areas lags 1 to 4 years behind in boys (Giedd, 2008; Lenroot et al., 2007; Lenroot & Giedd, 2011; Wierenga et al., 2017). Neuropsychological functions connected to these brain networks may, therefore, also lag behind in boys during this developmental period. This could explain why inattention, impulsive behaviors and poor planning abilities are characteristic for many boys in this age-period.

In addition to sex differences in brain maturation, differential engagement in sex-typed activities further fuel the differential development of neuropsychological abilities of boys and girls (Ceci & Papierno, 2005; Levine, Vasilyeva, Lourenco, Miller and Halpern, 2014; Newcombe & Huttenlocher, 2005). For instance, actions that are considered to be male-typical activities such as playing with construction toys or active engagement in video games can substantially improve spatial skills (Miller & Halpern, 2014; Uttal et al., 2013a; Uttal, Miller & Newcombe, 2013b). They even cause neural changes in cortical thickness (Haier, Karama, Leyba & Jong, 2009) and sex-differentiated patterns of brain activation (Jaušovec & Jaušovec, 2012). Boys therefore develop better spatial abilities than girls. The same may account for executive functions and self-regulatory skills: As teachers and parents expect adolescent girls to be further in their development than boys, they give more complex assignments to girls (e.g., assignments that require planning abilities or to focus for long periods of time). As these complex assignments appeal to executive functions and self-regulatory skills, they additionally stimulate development. The social environment (teachers, parents, neighbors, siblings) thus

has an essential role in the development of neuropsychological abilities and is therefore very important for personal growth. The social environment contributes to the development of behavioral acts, attitudes and affinities and thoughts that are often attributed to the biological sex of the child.

The findings done in previous studies on sex differences in executive functions and self-regulatory skills have been inconsistent. Many of these previous studies examined this notion in a study sample with very broad age ranges (e.g., 8–18 years). This is problematic as an increasing number of studies showed that the magnitude of sex differences on various cognitive abilities is influenced by age. For instance, results of the large-scale longitudinal study of Camarata and Woodcock (2006) showed that sex differences in information processing speed was relatively small in young children (aged 9 years and younger), larger in early adolescence (aged 10 to 13 years), and the largest in middle adolescence (aged 14 to 18 years). Moreover, Cross, Copping, and Campbell (2011) reported that sex differences in impulse control were more pronounced in adolescence than in adulthood. Results of both studies stress the need to examine the issue of sex differences in cognitive abilities during adolescence in narrow age classes. This is especially needed because when sex differences are investigated in groups with broad age ranges, larger sex differences at particular ages will be reduced by the smaller differences at other ages, and average evaluations of boys and girls will be almost equal. In this thesis, sex differences on various neuropsychological abilities are, therefore, investigated in samples with narrow age-ranges.

Parental education

It appears that brain development is fueled by experiences, intellectual stimulation and knowledge, and changing social demands. The social environment of the adolescent – i.e., teachers, parents, siblings, peers – is crucial because they provide the stimuli and challenges to the adolescent that are essential to stimulate rapid cognitive growth. Evidence for this notion comes from studies that reported on the importance of factors such as the level of parental education to the cognitive development of children (e.g., Ardila, Roselli, Mutate & Guajardo, 2005; Carr & Pike, 2012; Ganzach, 2000; Kautz et al., 2014; Noble, Houston, Kan & Sowell, 2012). Parents with higher education tend to create a more intellectually-stimulating environment for their children than lower educated parents (Carr & Pike, 2012; Hoff, 2003; Hoff, Laursen, Tardif & Bornstein, 2002). A stimulating environment creates the opportunity to gain experience with learning activities and to develop cognitive abilities (e.g., Evans, Kelley, Sikora & Treiman, 2010; Hackman, Farah & Meaney, 2010; Kautz et al., 2014; Lemos, Almeida

& Colom, 2011; Noble et al., 2012; Rindermann & Baumeister, 2015). Previous studies, for instance, demonstrated that higher educated parents have a different way of interacting with their children – particularly with respect to their motivational encouragement (Carr & Pike, 2012; Evans et al., 2010; Ganzach, 2000; Kautz et al., 2014; Meijs et al., 2009; Rindermann & Baumeister, 2015; van Soelen et al., 2009), and the language used (Hoff, 2003; Hoff et al., 2002). College-educated mothers talk more, use a richer vocabulary, and read more often to their children than mothers limited to high school education (Hoff, 2003; Hoff-Ginsberg, Holden, Fekken & Cotton, 1991). These stimuli further stimulate the development of brain structures and functions and the networks that they are involved in: Children from higher educated parents tend to have superior verbal abilities, larger vocabulary, and more rapid language development than children from lower educated parents (Carr & Pike, 2012; Ganzach, 2000; Hoff, 2003; Kautz et al., 2014). Next to differences in verbal abilities, differences between children with higher and lower educated parents have been demonstrated in problem-solving behavior and attention (Hurks et al., 2006; Meijs et al., 2009).

So far, the importance of parental education to learning performance has only scarcely been considered, with prior studies showing inconsistent findings. Investigating the influence of parental education on the neuropsychological development of adolescents is therefore needed to clarify the inconsistent findings in the literature. It enhances our understanding regarding the relation between parental education and academic achievement.

A multidimensional approach

Studying the developing adolescent requires a multidimensional approach. The home environment, school environment and the individual him/herself need to be taken into account. In clinical neuropsychological practices, information on each of these dimensions of the individual is acquired using observer-reports, self-reports and behavioral tests. For instance, teachers provide information about the student at school and parents provide information about their child at home. Self-reports can be used to gain information from the individual him/herself in various social contexts. Moreover, behavioral tests provide information about the individual's performance on a cognitive task and the behavioral reaction to a stimulus in a controlled setting. The studies in this thesis are performed from a neuropsychological perspective: The learning adolescent is studied using observer-reports, self-reports and behavioral tasks.

THESIS OUTLINE

Aim

The aim of this thesis was to study individual differences in the neuropsychological development of adolescents in relation to school performance. The determinants we focus upon were sex and parental education. The influence of these determinants was evaluated on particular neuropsychological abilities that are important to performance at school. These abilities involve particular executive functions, non-verbal learning processes and spatial information processing. The learning adolescent is studied using a multidimensional approach using teacher-, parent-, and self-reports as well as behavioral tasks.

Approach

Three large-scale cross-sectional studies were conducted to achieve the aim described above. One of these studies was a survey study. Each study involved a different population of pre-adolescents and adolescents in the age period between 7 and 22 years. The first was a cross-sectional study, *Schoolwise*, that included 310 healthy primary school-aged children. These children and adolescents attended third to sixth grade (age 8–12 years) of 4 regular primary schools in the urban Amsterdam region of the Netherlands. The parents and teachers of the children filled out a questionnaire and the children performed a neuropsychological test battery. All children were tested individually.

The second cross-sectional study, *BrainSquare*, included 1,081 healthy primary school-aged students. These students attended second to sixth grade (age 7–12 years) of 9 regular primary schools in the urban Amsterdam region of the Netherlands. They performed three neuropsychological test batteries. The study in this thesis focused on the results of one of these batteries. A group administration procedure was applied. Group administration enabling rapid and efficient data-collection.

The third population was a survey study performed by the *Wetenschappelijk Orientatie en Documentatie Centrum (WODC, Ministerie van Veiligheid & Justitie)*. This study included 3,118 adolescents aged 10–22 years. In this thesis, we use a part of this study sample including individuals aged 10–18 years ($n = 2,356$). The study sample is a representative selection of adolescents living in the Netherlands. The participants completed several questionnaires regarding their neuropsychological development and their involvement in delinquent acts.

Outline

The remainder of this thesis consists of 7 chapters. *Chapter 2* describes the influence of sex and parental education on teacher- and parent perceived executive functions and self-regulatory skills in 9-12-year-old schoolchildren. *Chapter 3* has its focus upon the influence of sex and parental education on the intentional learning of pictures in 8–12-year-old schoolchildren. *Chapter 4* describes differences in teacher-perceived executive functions and self-regulatory skills between children with high and low school achievement in schoolchildren aged 8–12-years-old. It also evaluates the influence of parental education to teacher-perceived executive functions and self-regulatory skills. *Chapter 5* gives the influences of sex on mental rotation ability. In *chapter 6*, the influence of sex on self-perceived executive functions and self-regulatory skills is described. *Chapter 7* focusses upon the importance of self-perceived executive functions and self-regulatory skills to delinquency. In *chapter 8*, the concluding remarks are given, in which the findings described in the preceding chapters are summarized and some remaining issues are discussed.

CHAPTER OVERVIEW

Chapter 2 Teacher evaluations of executive functioning in schoolchildren aged 9–12 and the influence of age, sex, level of parental education

This chapter describes a cross-sectional study in which age-related changes in executive functions as perceived and evaluated by teachers and parents were investigated, as well as the influence of sex and the level of parental education on their evaluations. The Amsterdam Executive Function Inventory (AEFI) was used which assesses three important components of the executive aspects of daily life behavior: Attention; Self-control and self-monitoring; and Planning and initiative taking. The sample tested included 186 schoolchildren aged 9-12 years. Possible differences in the perceptions of teachers and parents on the AEFI were studied as well.

Chapter 3 Boy-girl differences in pictorial verbal learning in students aged 8–12 years and the Influence of parental education

This chapter describes a cross-sectional study that evaluates factors which potentially determine individual differences in intentional learning in schoolchildren aged 8 to 12 years ($N = 152$). The importance of two

determinants was evaluated: the child's sex and the level of parental education. Intentional learning was assessed with a newly constructed Pictorial Verbal Learning Task (PVLT). This task presents line drawings of concrete objects as to-be-remembered information instead of written or auditory presented words. The PVLT has the advantage that performance is not confounded by individual differences in reading performance.

Chapter 4 **Teacher-evaluated self-regulation is related to school achievement and influenced by parental education in schoolchildren aged 8–12: A case-control study**

This chapter investigates two possible factors that contribute to individual differences in the school performances of children aged 8–12 years old: the self-regulation of the student and the educational levels obtained by their parents. The study first investigates whether children with high and low academic achievement differ in their self-regulation. It then evaluates whether there are differences in the self-regulation of children with high and moderate-to-low levels of parental education. The focus was on the self-regulation of students as judged by their teacher. Teacher evaluations were assessed using an observer questionnaire: the Amsterdam Executive Functioning Inventory.

Chapter 5 **Sex differences in the performance of 7–to 12–year olds on a mental rotation task: A large cross-sectional study**

This chapter investigates whether there are sex differences in mental rotation before the age of 10. It has been amply documented that from the age of ten onwards, boys perform better than girls on mental rotation tasks. It is, however, not clear whether this sex difference exists in younger children because there are no tasks suitable for evaluating mental rotation in young children. We therefore renewed an existing task for the investigation of mental rotation performance in children below the age of ten years. This renewed task – the Mental Rotation Task - Children – has a binary response approach in which children are required to indicate whether two graphic representations of three-dimensional cuboid figures are the same or not. This task was applied to 729 schoolchildren aged 7-to 12-years old in a cross-sectional study.

Chapter 6 Sex differences in self-regulation and self-insight in early, middle and late adolescence: A cross-sectional study

This chapter investigates whether there are sex differences in self-regulation and self-insight, in early, middle and late adolescence. It has been well established that adolescent boys and girls differ in academic achievements and in cognitive and behavioral development. Previous studies reported on the importance of self-regulation and self-insight to academic achievement and behavioral problems. This study took this notion one step further by evaluating differences in the self-regulation and self-insight of adolescent boys and girls, as this may contribute to the sex differences in academic achievement and behavioral problems. A cross-sectional study was conducted. The study involved more than 450 adolescent boys and girls aged 10–19 years. Sex differences were investigated in three age-ranges: Young, middle and late adolescence. Self-regulation and self-insight were evaluated with a self-report questionnaire: the Amsterdam Executive Functioning Inventory.

Chapter 7 The association between self-regulation and self-insight to delinquency

This chapter discusses the importance of self-regulation and self-insight – which are important executive functions – to delinquency. Both self-regulation and self-insight gradually improve over the course of adolescence. The levels of self-regulation and self-insight of individuals are thus lower in earlier adolescence than in later adolescence. This may explain why delinquency rates are higher in early and mid-adolescence than in late adolescence. The goal of this study was therefore to evaluate the association between self-regulation and self-insight to delinquency amongst a group of 554 juveniles in mid-adolescence (aged 14–18 years). Self-regulation and self-insight were evaluated with a self-report questionnaire: the Amsterdam Executive Functioning Inventory (AEFI).

Chapter 8 Concluding Remarks

This chapter discusses the major findings of the studies described in the previous chapters in relation to the central aim of this thesis. Overall, conclusions are discussed regarding (1) the influence of the determinants sex and parental education, (2) to individual differences in (perceived) executive functions, intentional learning and mental rotation ability, and (3) the importance of

executive functions and self-regulatory skills to school achievement and anti-social behavior. Moreover, interventions and possible implications for future research are given.