Childhood Self-Regulation, Academic Achievement and Occupational Attainment

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To Johanna! For sheer joy
and great ideas!

Abstract

The general aim of this thesis was to extend knowledge of the interplay between self-regulation (SR) skills during childhood in relation to academic achievement and later adult educational and occupational attainment.

Previous research has shown that cool SR (i.e., cognitive) is more closely linked to academic achievement than hot SR (i.e., motivational/emotional). However, studies investigating both cool and hot SR in relation to academic achievement have been restricted to young children. Therefore, Study I assessed cool and hot SR in relation to academic achievement over a longer time period. The results showed that cool SR at age 3 was related to achievement already at age 6. Hot SR at age 3 did not predict achievement until later on in elementary school.

Study II investigated the contribution of interference control and attention skills at age 6 to concurrent and later academic achievement at age 10. As the learning material becomes increasingly more complex throughout elementary school and teachers may give less support, interference control was expected to have a delayed effect on academic achievement relative to attention skills. Results showed that attention skills were related to academic achievement at age 6, whereas interference control only predicted academic achievement at age 10.

Study III investigated task persistence in young adolescence in relation to academic achievement later in school and educational and occupational attainment in midlife. Results showed that task persistence contributed to change in grades between ages 13 and 16. Further, task persistence predicted later educational and occupational attainment (men only). Importantly, individual differences in intelligence, motivation, social background, and later educational attainment did not account for these effects. The findings point to a fundamental role of self-regulation in childhood for successful academic achievement and later attainment in adulthood.

Keywords: Academic achievement, self-regulation, executive functions, school readiness, occupational attainment, educational attainment.

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Stockholm, April, 2012

List of studies

The present thesis is based on the following studies:

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2. Andersson, H., Grabell, A., & Olson, S. (submitted). Complex interference control in kindergarten and concurrent and later academic achievement.
3. Andersson, H., & Bergman, L. R. (2011). The role of task persistence in young adolescence for successful educational and occupational attainment in middle adulthood. *Developmental Psychology*, 47(4), 950-960. doi:10.1037/a0023786*

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Introduction

Most Western cultures regard education and work as central parts of an individual's life and crucial for the functioning of the society. Education has even been considered a foundation for democracy. Thomas Jefferson was keenly aware of this when he wrote, "If a nation expects to be ignorant and free, in a state of civilization, it expects what never was and never will be." (as cited in Padover, 1939, p. 89).

Furthermore, in most Western countries education and work are closely linked, as appropriate education is a prerequisite for the access to and the ability to perform many jobs. Further, the educational and occupational system is often designed in such a way that certain tasks (e.g., finishing school, attending college, choosing a career) are supposed to be accomplished at certain timepoints. If these timepoints are missed, it may be difficult to start over again and finish later on. In addition, individuals showing high competence early on in life tend to select and to be selected into more favorable environments than their less competent peers, giving the highly competent individuals a headstart in life that tends to persist throughout life (Clausen, 1991).

Acknowledging the importance of the development of good academic skills and academic achievement, it is of interest to study factors that contribute to successful attainment in school during childhood and adolescence. Also, previous research has underscored the importance of academic achievement and academic skills for later educational and occupational attainment along with factors such as socioeconomic status and intellectual ability (Strenze, 2007). However, a major part of the variance between individuals in later occupational attainment remains to be explained when these factors are taken into account (Bowles, Gintis, & Osborne, 2001). Understanding which other factors that account for individual differences in occupational and educational attainment is thus an important endeavor.

A perhaps obvious, yet less well understood, factor in explaining successful or less successful academic and vocational achievement is a child's ability to willfully exert behavioral control, that is, the child's ability for *self-regulation*. It is commonly assumed that children doing well in school are the smart children or the children who receive strong educational support from their parents. Moreover, we tend to assume that a child enrolled in a "good" school is more likely than a child enrolled in a "bad" school to perform better. Sometimes we hear of children beating the odds as they perform

above what would be expected given their background or level of competence. Typically, this is explained by that the child possesses an exceptionally strong will or ability to persist despite hardships. This idea has a long research history in psychology (Dewey, 1913; Eisenberger, 1992; MacArthur, 1955; Webb, 1915). However, it is not only in extraordinary situations that individuals need to be able to control themselves. We use self-regulatory skills throughout our lives: when we are trying to solve a novel problem, when we try to focus on a task that we find boring, or when we try to see a problem from a different point of view.

General Aims of the Thesis

The present thesis aims at investigating the contribution of different forms of self-regulation skills to academic achievement in childhood (Study I-II) and adolescence (Study III), and to educational and occupational attainment in adulthood (Study III). More specifically, Study I aims to assess whether regulation of motivation and impulses and regulation of cognitive processes differ in their contribution to academic achievement. Further, the importance of being able to solve cognitive conflict in relation to academic achievement will be studied (Study II). Finally, the role of task persistence will be investigated as a potential fundamental ability for successful attainment within education and work (Study III).

Self-Regulation in Childhood

Broadly defined, *self-regulation* refers to control of behavior, thoughts, and emotions in situations in which automatic and habitual responses are not appropriate for successful goal attainment (Barkley, 1997; Kopp, 1982; Stuss, Shallice, Alexander, & Picton, 1995). Barkley (2004) further states that self-regulation refers to “any action by individuals directed toward themselves, so as to change their behavior and therein alter future rather than merely immediate consequences” (p. 304). With this definition, Barkley makes a distinction between the outcome of an action (e.g., choosing a delayed rather than an immediate reward) and the self-directed actions required for obtaining a certain outcome. It is these self-directed actions that refer to self-regulation, not the outcome of these actions.

Self-regulation of behavior is involved in many situations: to comply to a request, to initiate a behavior, to stop a behavior according to the demands of the situation, to modulate the intensity, frequency, and duration of verbal or motor acts in different settings, to inhibit an impulse to act on a desired object or goal for an immediate reward in favor for a delayed reward, planning, nonroutine problem-solving, or to act according to social norms in the absence of external monitors (Barkley, 1997; Eisenberg, Smith, Sadovsky & Spinrad, 2004; Kopp, 1982; Mischel, Shoda & Rodriguez, 1989; Rothbart & Bates, 1998; Stuss et al., 1995). Beginning in infancy, self-regulation develops from a more or less automatic process - the child reacts to the environment in a reflexive way - to a more complex process of increasing voluntary control, which becomes less dependent on the environment and more controlled by the individual's conscious and willful acts (Barkley, 1997, 2001; Kopp, 1982). Kopp (1982) describes different stages of the development of self-regulation. Before age 2, control skills are highly dependent on the presence of signals from the environment because the child cannot yet recall events. With the emergence of mental representation and evocative memory around age 2, the child begins to be able to delay an act when requested to and can behave according to social expectations without external monitors. Typically, the child can now use symbols instead of the presence of objects for control and with it, the child starts to understand social rules. The forces driving the development of self-regulation have been linked to the development of neurological networks (mainly within prefrontal cortex), the child's learning history of self-regulatory actions and their consequences for behavior, socialization processes, and history of reinforcement for performing self-

regulatory actions (Barkley, 1997; Eisenberger, 1992; Fuster, 2008; Zelazo, Carlson, & Kesek, 2008).

The study of self-regulation in childhood can be divided into two main traditions: the cognitive and the temperament tradition. First, I will briefly introduce these two traditions and later place them within the framework of cool and hot forms of self-regulation.

The Cognitive Tradition

Within the cognitive tradition, the child's ability for self-regulation is often described as a set of executive functions. Collectively, executive functions refer to the psychological processes involved in the conscious control of thought, attention, and behavior (Fuster, 2008; Garon, Bryson, & Smith, 2008; Stuss et al., 1995). Exactly what these executive functions are and which underlying processes that subserve them are less clear. One claim is that variation in performance on executive tasks can be attributed to a unified system, although the nature of this system differs between researchers. Some suggestions are the capacity for inhibitory control (Dempster, 1992), working memory capacity (Engle, Tuholski, Laughlin, & Conway, 1999), working memory strength (Munakata, 2001), a supervisory attention system (Norman & Shallice, 1986), or the complexity of the cognitive rule system (Zelazo, Carter, Reznick, & Frye, 1997). A second claim is that there are separate but interrelated subprocesses. These models often include inhibitory control and working memory (e.g., Diamond, 2002; Diamond, Kirkham, & Amso, 2002), and a shifting component (e.g., Diamond, 2002; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). Despite the controversy of the nature of executive functions, these models commonly refer to control processes that are fairly neutral with respect to motivation and emotion (Kerr & Zelazo, 2004; Zelazo & Müller, 2002).

The Temperament Tradition

The temperament tradition assumes two overarching control systems: the reactive system and the self-regulatory system. The latter is often referred to as effortful control and is defined as "the ability to inhibit a dominant response in order to perform a subdominant response" (Rothbart, Ellis & Posner, 2004, p. 362). It should be noted that this definition fails to specify what the ability to inhibit a dominant response actually is.

Temperament is a biologically based construct and refers to "constitutionally based individual differences in reactivity and self-regulation, as seen in the emotional, motor, and attentional domain." (Rothbart et al., 2004, p. 357). The reactive system controls approach-avoidance tendencies in relation

to aversive and appetitive stimuli (Corr & McNaughton, 2008; Gray, 1982; Gray & McNaughton, 2000; Rothbart & Bates, 1998). One theoretical model frequently used to describe these tendencies is Gray's reinforcement sensitivity theory (Corr & McNaughton, 2008; Gray, 1982; Gray & McNaughton, 2000). In its present state, this theory postulates three major emotion/motivation systems: the Fight-Flight-Freeze System (FFFS, mediates reactions to conditioned and unconditioned aversive stimuli), the Behavioral Approach System (BAS, mediates reactions to conditioned and unconditioned appetitive stimuli), and the Behavioral Inhibition System (BIS, mediates the resolution of goal conflict in general; Pickering & Corr, 2008). An important point is the fact that the BAS is not equal to impulsive behavior, even if it includes such behaviors (Corr, 2008). The primary function of the BAS is to "move the animal up the temporospatial gradient to the final biological reinforcer" (Corr, 2008, p. 19). At early stages of approach towards the goal, functions such as behavioral restraint and planning are often necessary for successful goal attainment. At these early stages, impulsive behavior is typically detrimental and has to be restrained (Corr, 2008). Even though the BAS may entail functions such as behavioral restraint and planning, it is a lower-order system functioning out of awareness, and in turn, it does not demand any self-awareness or higher-order consciousness to function (Corr, 2008).

The exact relation between these automatic reactive systems (BIS, BAS, FFFS) and higher-order cognitive control systems is still unclear. One general idea is that the direct (on the time-scale of milliseconds) stimulus-response reactions controlled by the reactive systems are always non-conscious and beyond voluntary control. Thus, higher-order cognitive processes can only influence the reactive systems at a second stage of processing (at the time-scale of hundreds of milliseconds), for example by biasing future processing of stimuli via attention control (Corr, 2008).

An important point is that, on a conceptual level, the development of self-regulation within the temperament tradition describes the increasing control the child gains over her/his own reactive approach-avoidance tendencies. In this sense, it is fair to say that the cognitive tradition, as stated above, deals with emotionally and motivationally neutral control, whereas the temperament tradition is more concerned with control over emotion- and motivation based reactive tendencies. Additionally, the division between reactive and effortful/voluntary control has the consequence that when investigating the role of self-regulation in relation to adaptation, it is important to take the child's reactive temperament into account. For instance, when a child with a highly reactive behavioral approach system (i.e., a strong tendency to approach reward) is doing homework and tries to delay the immediate gratification of instead playing a computer game, this child will have more reactive impulses to regulate compared to a child in the same situation who has equal self-regulatory skills but a less reactive BAS. Therefore, it is important to

account for individual differences in the reactive system; otherwise one may draw wrong conclusions about individual differences in self-regulatory skills.

The Hot and Cool Distinction of Self-Regulation

Within several areas of psychology, a broad distinction has been made between self-regulation that occurs in tasks that are mostly emotionally/motivationally neutral (e.g., standard working memory tasks) and self-regulation in tasks that involves motivationally and emotionally salient stimuli or outcomes (e.g., delay of gratification tasks; Bush, Luu, & Posner, 2000; Hongwanishkul, Happeney, Lee, & Zelazo, 2005; Krain, Wilson, Arbuckle, Castellanos, & Milham, 2006; Zelazo & Müller, 2002). Zelazo and Müller (2002) termed these *cool* (i.e., emotionally/motivationally neutral tasks) and *hot* (i.e., emotionally/motivationally salient tasks) forms of self-regulation, although they used the term executive functions instead of self-regulation. However, Hongwanishkul et al. (2005) stressed that the distinction between hot and cool forms of self-regulation is not clear-cut, even if a theoretical and conceptual distinction can be made between the two. Most tasks requiring self-regulation involve both hot and cool forms of self-regulation, especially in real life tasks and when children are involved. For example, a child performing a (cool) working memory task might get excited when working on the task, and in turn has to regulate a non-optimal level of arousal. The point is that some tasks (e.g., not to eat the forbidden cookie) will require more hot self-regulation and other tasks (e.g., keeping task relevant information in an active state of mind) will be more dependent on cool self-regulation.

The rationale for a general distinction between hot and cool self-regulation comes from several sources of evidence. Neuropsychological findings have shown that hot tasks to a higher extent recruit ventral and medial portions of the prefrontal cortex (PFC) and posterior anterior cingulate cortex (ACC) when compared to cool tasks, whereas cool tasks engage dorsolateral PFC and anterior ACC to a higher extent (Bush et al., 2000; Fuster, 2008; Krain et al., 2006). Further, lesions to the ventromedial PFC in humans disrupt reward based decision-making and perspective-taking. Moreover, persons with such lesions are typically unable to observe social conventions and become more impulsive than subjects without lesions in delay of gratification tasks. Importantly, individuals with lesions to the ventromedial PFC often have intact intellectual abilities, normal learning and memory functions, and perform within the normal range on many cool executive function tasks (Bechara, Damasio, & Damasio, 2000; Eslinger, Flaherty-Craig, & Benton, 2004). In a study of marmoset monkeys, surgical damage to lateral PFC (LPFC) but not orbitofrontal cortex (OFC; often described as a part of

ventromedial PFC) impaired attentional set shifting ability (switching from one dimension to another; Dias, Robbins, & Roberts, 1996). In contrast, reversion of a stimulus-reward association (i.e., hot self-regulation), which did not require attention switching, was impaired by a lesion to the OFC but not to the LPFC. The authors speculated that the deficit following a lesion to the OFC involved a failure to suppress the influence of previously acquired stimulus-reward associations (i.e., the subjects continued to respond to the previously but no longer rewarded stimuli), but with an intact ability to learn new stimulus-reward associations.

Developmental evidence of a hot/cool distinction has been supported by findings showing that children's hot self-regulation displays a delayed development relative to cool forms of self-regulation (Prence et al., 2011). Similarly, it has been found that 3-year olds, when asked to point to a smaller reward in order to receive a larger reward (children were told that the reward they pointed to would be given away and that they would receive the other reward) had difficulties performing this task (Carlson, Davis, & Leach, 2005). On the other hand, 4-year olds performed the task well. However, if the rewards were replaced by symbols (e.g., a mouse and an elephant), 3-year olds managed to perform the task. That is, 3-year olds were unable to suppress or implement top-down control over the prepotent response - pointing at the larger reward - when the task required hot regulation, but not when the task only required cool regulation.

Further, a dual-pathway model has been suggested to explain the symptoms related to ADHD and this model is in line with a hot/cool distinction (Sonuga-Barke, 2002; Sonuga-Barke, Dalen, & Remington, 2003). The first path leading to ADHD problems is the "cool" path, describing a deficit in inhibitory control. This deficit in turn influences thought and attention processes. The second path leading to ADHD problems is the "hot" pathway that describes individual differences in motivational style, defined as the unwillingness to wait for delayed rewards and events (i.e., delay aversion). It has been suggested that these differences in motivational style are caused by an alternation in underlying reward mechanisms, for instance through an alternation in the discounting rate of delayed reward value. That is, individuals with delay aversion problems have a history of discounting future reward value at a higher rate than normal individuals and this in interaction with the environment leads to later delay aversion problems (Sonuga-Barke, 2002). Support for this model comes from studies showing that children with ADHD choose small immediate rewards over larger delayed rewards more often than do controls (Sonuga-Barke, Taylor, Sembi, & Smith, 1992). Also, deficits related to cool self-regulatory functions and delay aversion have been shown to independently predict ADHD symptoms (e.g., Solanto et al., 2001).

Finally, it is important to note that in the area of hot self-regulation, as in the area of cool self-regulation, separate subprocesses have been suggested.

For example, Reynolds and Schiffbauer (2005) made a distinction between *delay of gratification*: the “[...] ability to sustain a choice for a delayed reward while a smaller immediate reward is continually available” (p. 440), and *delay discounting*, focusing on the initial-choice response in the sense that a choice is made between an immediate smaller reward or a delayed larger reward, and once the choice is made, it is definite (but see above for the relation between delay discounting and delay aversion in relation to ADHD problems). Typically, children younger than 8 or 9 years do not show discounting of reward value as a function of delay, but even for 3-year olds, individual differences in performance on delay of gratification tasks predict long-term outcomes (Mischel et al., 1989; Reynolds & Schiffbauer, 2005; Shoda, Mischel, & Peake, 1990). In the present thesis, the ability to withhold a response in the presence of a reward was investigated, seen as one aspect of delay of gratification. Hot self-regulation also involves the regulation of emotions but this aspect was not specifically investigated in the present work.

Two Forms of Cool Self-Regulation and Task Persistence

In the present thesis I will focus on two forms of cool self-regulation: attention control/skills (Study I and II) and interference control (Study II). Even though both these forms are mainly cognitive and motor control based constructs, they have been investigated within both the cognitive and the temperament tradition. Attention control is regarded as a fundamental skill for more complex cognitive, behavioral, and emotional control within both traditions (e.g., Rothbart & Bates, 1998; Stuss et al., 1995). Further, even if interference or inhibitory control (i.e., the ability to suppress a dominant response in favor of a less dominant response) is included in the definition of self-regulation within the temperament tradition, the most extensive research comes from cognitive psychology and cognitive neuroscience (e.g., Dempster & Corkill, 1999; Diamond, 2002; Munakata et al., 2011; Stuss et al., 1995; Zelazo et al., 2008). As will be described below, the study and explanation of interference control is an area of extensive debate between two major models of self-regulation (executive functioning) within cognitive psychology. One model favors *activation* as a basic process, and the other favors *interference control or inhibition* as the most important process. Both models have been suggested in explaining the development and decline of self-regulation over the life span as well as in explaining phenomena such as reading and math difficulties (Dempster & Corkill, 1999; Lustig, Hasher, & Zachs, 2007; Ridderinkhof & van der Molen, 1997).

This chapter will end with a description of task persistence: A self-regulatory capacity that was investigated in Study III and that includes aspects of both cognitive and motivational/emotional control.

Attention control

Attention does not refer to a unitary construct or mechanism (Chun, Golomb, & Turk-Browne, 2011; Goldhammer, Moosbrugger, & Schweizer, 2007; Stuss et al., 1995). However, a basic function of attention is to allocate limited processing capacity to the most relevant information in a given situation, as humans have a limited capacity to simultaneously process all information presented by the environment and the internal state. A second basic characteristic of attention is the ability to sustain vigilance while selecting and modulating relevant information (Goldhammer et al., 2007; Sarter, Givens, & Bruno, 2001). Posner and Rothbart (1998, 2007) have developed a framework that aimed to integrate the concepts of attention and self-regulation, and to relate these to the biologically based concept of temperament. They suggested three attentional networks: (1) the *alerting network*, involved in the adjustment of general alertness when vigilance must be sustained over long periods of time; (2) the *orienting network*, involved in orienting attention to sensory events. These two networks together align attention to a sensory stimulus of interest; (3) the *executive network*, providing the basis for voluntary action and handling of conflicts, and regulation of the orienting network. The executive attention network begins to emerge during the first year of life, but its major development takes place between ages 2 and 7. After age 7, development is gradual (Betts, McKay, Maruff, & Anderson, 2006; Rebok et al., 1997; Ruff & Lawson, 1990). The development of voluntary control over attention sets the stage for the development of more complex forms of self-regulation (Chun et al., 2011; Stuss et al., 1995).

Based on these networks, the models put forward by Posner, Rothbart (1998, 2007) and others (e.g., Coull, 1998; Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991; Stuss et al., 1995) distinguish between different components of attention. Most of these models share the components of alertness, focused attention, sustained attention, divided attention, spatial attention, and attentional switching (Goldhammer et al., 2007). The focus of the present thesis is on the component focused attention, also referred to as concentration (Alexander, Stuss, Shallice, Picton, & Gillingham, 2005). Focused attention is seen as separate from sustained attention (or vigilance), as focused attention refers to the allocation of attention resources in demanding cognitive tasks or to rapidly occurring relevant stimuli, whereas sustained attention is required when relevant stimuli occur at a slow rate over longer periods of time, in turn demanding that a high level of vigilance is upheld (Sarter et al., 2001; Stuss et al., 1995).

Interference Control

A basic characteristic of self-regulation is that thoughts and behaviors are guided by plans, goals, and intentions. Fundamental for the execution of these processes is that relevant information or schemas must be activated, either automatically, or when required, deliberately by the individual (Ridderinkhof & van der Molen, 1997; Stuss et al., 1995). In addition, information or schemas irrelevant or distracting for the task at hand must be suppressed (Pascual-Leone & Baillargeon, 1994). Interference control or inhibitory control refers to this ability to suppress, inhibit, or ignore irrelevant information while executing a task (Dempster & Corkill, 1999; Lustig et al., 2007). The term interference control is typically used to describe control over cognitive processes, whereas inhibitory control refers to the control of motor responses, even though there is often no sharp distinction between cognitive and motor inhibitory control, as many tasks include aspects of both.

Hasher and Zacks (1988) defined three basic forms of interference control (they used the term inhibitory control): access, deletion, and restraint. In this model, inhibitory control is central to the effective operation of working memory (i.e., the active maintenance and manipulation of task relevant information), which in turn is crucial for the performance on many tasks (e.g., language comprehension and problem-solving). Access refers to the prevention of irrelevant information from entering into working memory. Depending on the nature of the distracting stimuli (i.e., detrimental or facilitating in relation to the task), deficits in the access function can both disrupt or facilitate performance (Lustig et al., 2007). The deletion function is needed to quickly inhibit irrelevant information that has entered into working memory. For instance, this is important in directed forgetting tasks and in the suppression of irrelevant meanings of ambiguous words (Gernsbacher, 1993; Lorbach, Wilson, & Reimer, 1996). Finally, the restraint function refers to the ability to withhold a prepotent but inappropriate response. This is likely the most investigated form of inhibitory control, evident in go/no-go tasks in which a behavior is performed (e.g., pressing a button) in relation to a stimulus and the same behavior should be suppressed when another less frequent stimulus is presented (Gomez, Ratcliff, & Perea, 2007). In more complex interference control tasks, all three of these functions are probably needed to a varying degree.

Inhibitory and interference control skills have an extremely slow developmental progression, not reaching full maturity until early adulthood (Diamond, 2002). For example, in the directed forgetting paradigm (participants are instructed to forget certain words and to remember other words they have encoded), 11-year-olds show more intrusions of the to-be-forgotten words than do adults (e.g., Harnishfeger & Pope, 1996). The development of interference control begins during the first year with the emergence of simple

response inhibition (e.g., the ability to stop an enjoyable activity upon request from the parent; Garon et al., 2008). Later on, the child develops the ability for more complex inhibitory and interference control that also place demands on working memory (e.g., holding an arbitrary rule in mind). On simpler forms of these tasks, such as the bear and dragon game, in which the child is required to perform the action as told by one puppet and to inhibit the behavior as told by the other puppet, major development takes place during the third year (Best, Miller, & Jones, 2009; Carlson, 2005).

As stated above, accounts aiming to explain performance on interference control tasks either stress the importance of *activation of task relevant schemas* (e.g., Engle, Conway, Tuholski, & Shisler, 1995; Munakata et al., 2011) or highlight the importance of *suppression or inhibition of task irrelevant schemas or information* (e.g., Dempster & Corkill, 1999; Ridderinkhof & van der Molen, 1997). Although both approaches usually acknowledge the importance of activation and suppression functions in executive control of thought, emotion, and behavior, typically one function is favored over the other. For instance, several single capacity or resource models aim to explain growth in cognitive control and general cognitive development. A common model supporting an activation account is to postulate a limited memory span resource referred to as working memory (Case, 1987) or mental capacity (Pascual-Leone, 1970). Others also stress the fundamental importance of being able to sustain attention on the task and to maintain task goals active in working memory, especially when faced with external or internal distracters, in the executive control of behavior in interference situations (e.g., Mecklinger, Weber, Gunter, & Engle, 2003; Unsworth, Redick, Lakey, & Young, 2010).

Even though activation processes such as working memory are important for the performance on interference tasks, these processes cannot solely explain several findings on the development of interference task performance. For instance, between ages 3 to 7, children show strong improvement in performance on tasks that require the child to hold arbitrary rules in mind and simultaneously suppress prepotent responses. In the Day-Night task the child is asked to respond with “day” to a picture of the moon and “night” to a picture of the sun. Children between ages 3.5 and 4.5 find this task very difficult, but at age 6 to 7 they perform it easily. However, if abstract designs are used as stimuli instead of pictures of sun and moon, even 3.5-year olds perform well on the task. Thus, it is not the demand of holding two arbitrary rules in mind that younger children have problems with, but to inhibit a prepotent response. What makes these kind of tasks challenging is foremost the fact that they are misleading situations. Pascual-Leone (1985) defined misleading situations as situations in which the context elicits schemes that interfere with the correct performance of the task. This contrasts with facilitating situations in which the context elicits schemes that are compatible with

the task. For example, the non-linear stagewise development as described by Piaget is only reliably found in misleading situations (Pascual-Leone, 1996).

A second parameter that contributes to the difficulty in some of these tasks is the demand to switch between performing the prepotent response and to withhold or performing a response counter to the prepotent response. An example of this is the Simon Says task. In this task, the child is instructed to perform the same behavior as the instructor (e.g., the instructor says "touch your head" and at the same time touches her/his head), but only when the words "Simon Says" precedes the instruction, otherwise the child is supposed to be still. Thus, the child has to switch between following direction and to inhibit the prepotent response to imitate the instructor. Six-year olds find this task challenging (note that even adults rarely show ceiling effects on this task; Diamond, 2002). The switching demand prevents the child from using the strategy of actively suppressing the prepotent response and the consequence is that the automatic impulse to perform the prepotent response becomes stronger in tasks that demand the child to switch. Young children (< 4 years) also have problems in tasks that demand switching between response criteria but lack inhibition demands (Diamond, 2002; Zelazo Reznick, & Piñon, 1997). Further, in tasks that do not require either switching or inhibition, but demand that the child holds 4 stimuli-response rules in mind, even children as young as 3 years perform well (Zelazo et al., 1995). This further supports the notion that working memory demands are not the main problem facing children in these tasks.

A third parameter contributing to task difficulty in interference control tasks is the strength of the prepotent response (Ridderinkhof & van der Molen, 1997). For example, Diamond and Taylor (1996) argued that the reason why preschool children perform better on Luria's hand game (the child is instructed to make a fist when the instructor shows fingers and vice versa) than on the Day-Night task is that the prepotent response to say "day" to the sun is stronger than to imitate hand gestures in the hand game. This can also be seen in the higher difficulty of the Simon Says task compared to the Day-Night task: the prepotent response is stronger in the Simon Says task because the person the child imitates gives both a verbal instruction and performs the behavior (Carlson, 2005).

Other suggestions have also been put forward to explain the increase in interference control during childhood and adolescence, such as higher processing speed (Kail & Salthouse, 1994), but others argue against this notion (Ridderinkhof & van der Molen, 1997). Note that I am not suggesting that increased interference control completely explains improved performance on many self-regulation tasks during childhood, but that it is an important factor in interference tasks. However, increased interference control has also been suggested to play an important role in performance on working memory tasks (Lustig et al., 2007).

Task Persistence

Task persistence is a complex self-regulatory skill linked to several cognitive and motivational factors. The ability to persist on a task can be influenced by motivation traits like need for achievement and mastery motivation (Atkinson, 1960; Feather, 1963; Sigman, Cohen, Beckwith, & Topinka, 1987), the person's skill level, perception of task difficulty (Sigman et al., 1987), and self-perception (Houser-Marko & Sheldon, 2006). Two fundamental skills related to task persistence is the ability to focus attention on a task and the ability to handle mental effort and frustration (Deater-Deckard, Petrill, & Thompson, 2007; Sigman et al., 1987).

Behavior suggesting task persistence (i.e., the time a person works on a task) will be closely linked to intellectual ability and motivation. Finding the task rewarding, not too difficult and feeling confident in that the task will be solved will surely make a person work longer compared to a person who finds the task boring, very difficult and with low confidence of success. This is not the form of task persistence at focus here. Instead, in the present thesis task persistence is more similar to what MacArthur (1955) referred to when defining persistence as "that quality by virtue of which an individual continues in steadfast pursuit of an aim, in spite of difficulties or obstacles" (p. 43). More precisely, persistence in the present thesis is defined as, given equal intellectual abilities and motivation, the ability to persist and to focus attention at a task, even in the presence of mental effort and internal and external distractions. Similarly, Webb (1915) defined *persistence of motives*, a dimension of the trait *will*, as the tendency not to end a task for mere changeability and to endure when faced with obstacles. The etiology of task persistence is less known, but probably involves factors such as temperament (Martin Wisenbaker, & Huttunen, 1994; Ryans, 1939), learning history (Eisenberger, 1992), and personality (Shiner & Caspi, 2003; Webb, 1915).

In temperament research using factor analytic methods, task persistence has been found to be a separate lower-order trait (Martin et al., 1994). Further, MacArthur (1955) used factor analysis on a battery of 21 tests in a sample of 120 boys in secondary school tapping different aspect of persistence and found a general persistence factor explaining 34% of the variance. This general persistence factor was related to school achievement, controlling for intelligence. In personality research, spanning over both childhood and adulthood, persistence is often described as a lower-order trait within the higher-order trait of conscientiousness (Caspi & Silva, 1995; Shiner, 1998; Shiner & Caspi, 2003).

Several studies have found moderate to high stability of task persistence and the higher order trait conscientiousness in childhood and from adolescence into adulthood (Caspi & Silva, 1995; Judge, Higgins, Thoresen, & Barrick, 1999; Klimstra, Hale, Raaijmakers, Branje, & Meeus, 2009). For example, Judge et al. (1999) found an average corrected correlation of .56 in

conscientiousness from young adolescence into late adulthood. Roberts and DelVecchio (2000) found an average corrected correlation of .36 for task persistence during childhood and early adolescence (holding age and time interval constant) in their large meta-analysis of temperament and personality rank-order consistency. Finally, research has further shown that most of the interindividual stability in task persistence could be accounted for by genetic influences (Deater-Deckard, Petrill, Thompson, & DeThorne, 2006). At the individual level, persistence shows developmental increase at least into middle adolescence (Lufi & Cohen, 1987; Ryans, 1939).

A related concept that has bearing on the persistence concept is the theory of learned industriousness (Eisenberger, 1992). Central to the theory is mental effort. Dewey (1913) described mental effort eloquently when he wrote “Effort, as a mental experience, is precisely this *peculiar combination of conflicting tendencies* – tendencies away from and tendencies towards: dislike and longing” (p. 49). Eisenberger (1992) describes it similarly as an aversive, subjective experience that occurs when information processing or physical motion are obstructed or fatigued. Effort can be measured as the degree to which an individual persists on a task despite the lack of reward, or the degree to which an individual is able to work for delayed reinforcement. In short, the theory states that if a person invests a large amount of cognitive or physical effort into some task and is rewarded for that, the sensation of high effort turns into a secondary reinforcement that decreases the innate aversiveness of effort. This secondary reinforcement of effort may generalize into other areas and makes the person more ready to expend effort in goal-directed tasks. In contrast, if an individual is rewarded for low effort, it would take on secondary reinforcement and be preferred over higher effort. If low and high efforts are given the same reward, the secondary reinforcement of high effort will disappear, and high effort becomes aversive (Eisenberger, 1992). It follows that students who are rewarded each time they finish a small assignment with low perceived effort are less likely to exert high effort in another task, as they would have been, had they been rewarded each time they finished several demanding tasks with high experienced effort. Therefore, part of the etiology of task persistence perhaps lies in that individuals high in task persistence have a learning history of secondary reinforcement of high effort.

The Role of Self-Regulation in School Readiness and Academic Achievement

There is no consensus regarding the definition of school readiness, what it ought to measure or how to measure it (Blair, 2002; Crnic & Lamberty, 1994). Nevertheless, some robust early predictors of later school achievement have emerged. As indicators of school readiness, early literacy and numeracy skills are often the strongest predictors of later achievement (e.g., Alexander & Entwisle, 1998; Duncan et al., 2007; La Paro & Pianta, 2000; Romano, Babchishin, Pagani, & Kohen, 2010). In addition, intellectual ability (Hess, Holloway, Dickson, & Price, 1984; Lassiter & Bardos, 1995) and socioeconomic status (Sirin, 2005) are early childhood predictors of later academic achievement. Importantly, children showing early academic and learning difficulties are not only at risk for later academic difficulties but also social problems, such as peer rejection and emotional or behavioral disorders (Normandeau & Guay, 1998).

One major factor that has been suggested to make the child ready for school is good self-regulatory skills (e.g., Blair, 2002). In their definition of behavioral school readiness, Campbell and von Stauffenberg (2008) included social and self-regulatory skills that help the child to deal with expectations in the classroom. These expectations include both adjustment and attainment behaviors often related to different learning behaviors: being able to participate effectively in classroom routines and learning activities, follow rules, stay on-task, and to follow teachers' directives (Bierman, Torres, Domitrovich, Welsh, & Gest, 2008). In line with the suggested importance of self-regulation for academic achievement, a growing number of studies have found that different forms of self-regulation abilities in preschool and kindergarten are important for the development of good school-readiness skills (e.g., Blair & Razza, 2007; Fuhs & Day, 2011; McClelland et al., 2007) and later academic achievement (e.g., Duncan et al., 2007; Romano et al., 2010; Zhou, Main, & Wang, 2010).

Working memory is perhaps the most investigated self-regulatory construct in relation to academic achievement (e.g., Bull & Scerif, 2001; Bull, Espy, & Wiebe, 2008; Swanson, 2003, 2006; Swanson & Jerman, 2007; see Carretti, Borella, Cornoldi, & De Beni, 2009, for a meta-analysis of working memory in relation to reading comprehension difficulties; see Raghubar, Barnes, & Hecht, 2010, for a review of working memory in relation to math-

ematical skills). Given that working memory describes the ability to maintain, manipulate, and control information online in a mental workspace, its potential relevance for handling the demands of learning in school is quite obvious, although the nature of the direct relationship needs further investigation (Raghubar et al., 2010). I will not further elaborate on this subject, as working memory is not the focus of the present thesis, only briefly describe its relation to other aspects of self-regulation and academic achievement.

Within the temperament tradition, most researchers have used questionnaire data when investigating the link between self-regulation and academic achievement (e.g., Kurdek & Sinclair, 2000; Martin & Holbrook, 1985; Martin, Nagle, & Paget, 1983; Normandeau & Guay, 1998; Schoen & Nagle, 1994; Valiente, Lemery-Chalfant, & Castro, 2007; Valiente, Lemery-Chalfant, Swanson, & Reiser, 2008; Zhou et al., 2010), although not exclusively (e.g., Liew, Chen, & Hughes, 2010; Liew, McTigue, Barrois, & Hughes, 2008). In addition, these studies did not distinguish between hot and cool forms of self-regulation, as general measures including both aspects were used. If, as will be argued for later, cool and hot forms of self-regulation are important for the development of good academic skills and follow different developmental time lines, it is necessary to separate these aspects of self-regulation when studying them.

Next, the four aspects of self-regulation investigated in the present thesis (i.e., attention skills, delay of gratification, interference control, and task persistence) will be described in relation to their role in academic achievement stretching the period from preschool (Study I) and kindergarten (Study I and II) into late elementary school (Study I-II, age 10) and middle and late compulsory school (Study III, age 13-16).

Early Attention Skills in School

A basic skill for dealing with the demands of school is the ability to focus attention on a task. Good attention skills also allow the child to quickly return to task relevant behavior when distracted. According to Hall (2003), “no matter how structured or self-regulated the curriculum is, it will always include long stretches of reading and/or listening to lectures” (p. 193). Hall further writes, “It is far more common that our minds wander off while reading or listening than we notice introspectively” (p. 195), and concludes that the management of interruptions is “a far more costly activity than normally acknowledged” (p. 151).

These basic processes further promote the child’s learning via a positive feedback loop in which new material is easier to learn if the child has already managed to focus on and learnt previous material (Duncan et al., 2007). Besides focusing on the task at hand, several tasks in school, especially in mathematics, involve a relatively laborious series of steps, which often have to be kept in an active state of mind (Fuchs et al., 2006). Lapses in at-

tention may force the child to start the problem-solving process over from the beginning and if this happens too many times, the child may give up. Supporting this notion, studies have shown that children with mathematic disabilities monitor problem-solving less well than children without mathematic disabilities (Butterfield & Ferretti, 1987; Geary, Widaman, Little, & Cormier, 1987). As described earlier, the ability to focus attention is a prerequisite for many other self-regulatory skills important for learning and achievement in school such as interference control and working memory (Garon et al., 2008; Rueda, Posner, & Rothbart, 2004).

Even though most studies investigating the impact of self-regulation in childhood on academic achievement have not included direct measures of attention skills (however, several studies within the temperament tradition have included attention skills in their broad measures of effortful control), studies that have included direct measures show that attention skills indeed are strong predictors of concurrent and later academic achievement (Duncan et al., 2007; Edley & Knopf, 1987; Fuchs et al., 2006; Lan, Legare, Ponitz, Li, & Morrison, 2011; Miller & Hinshaw, 2010; NICHD, 2003; Trentacosta & Izard, 2007; Valiente, Lemery-Chalfant, & Swanson, 2010; Vitiello, Greenfield, Munis, & George, 2011). One of the main themes of this thesis is to study the importance of early self-regulatory skills during preschool and kindergarten for later academic achievement (Study I and II). There are a few longitudinal studies investigating the relation between early attention skills and academic achievement spanning longer time periods than a year, but the main findings are based on broad questionnaire measures of attention skills. These studies mostly support the importance of good early attention skills for later successful academic achievement, while controlling for several factors like early academic skills, intellectual ability, and parents' socioeconomic status (Duncan et al., 2007; Kohn & Rosman, 1974; Pagani, Fitzpatrick, Archambault, & Janosz, 2010; Rabiner, Coie, & The Conduct problems prevention research group, 2000; Romano et al., 2010). However, none of these studies have investigated whether attention skills early on in the important developmental period between ages 2 to 7 had an impact on the development of good academic skills into late elementary school.

Interference Control in School

Research seems to support the notion that the ability to suppress task irrelevant information from entering into working memory and to delete irrelevant information from working memory is related to problem-solving, reading comprehension, and to different forms of learning disabilities (e.g., Cain, 2006; Dempster & Corkill, 1999; Lersbach et al., 1996; Passolunghi & Siegel, 2001). For instance, less skilled readers have shown difficulty in suppressing the inappropriate meaning of ambiguous words (Cain, 2006; Gernsbacher & Faust, 1991). Lersbach et al. (1996) showed that skilled and

less-skilled readers activated multiple meanings of ambiguous words equally well, but after a brief delay, skilled readers were better at suppressing the contextually inappropriate meanings than less-skilled readers. A deficiency in interference control may also have other consequences. For instance, poor interference control may result in difficulties in abandoning recently activated associations while listening to a lecture, when having a conversation, or when reading a text. This may result in difficulties when the topic changes. Remaining old associations could hamper new relevant associations to emerge when new information is presented.

Another consequence of poor interference control has been suggested by Gernsbacher and Faust (1991) in explaining why less-skilled comprehenders (e.g., when learning text, audio, or visual information) forget recently comprehended material quicker than skilled comprehenders. They argue that when we learn new material we build up a cognitive substructure. When we switch to new information, we build up a new substructure, and the new substructure interferes with the old substructure, making it less accessible. Because of the suggested deficit in interference control, less-skilled comprehenders may have a difficulty in suppressing irrelevant information. The activated irrelevant information makes the less-skilled comprehenders shift too often to build a new substructure based on the activated irrelevant information. This results in too many substructures and poorer access to relevant information (i.e., substructures). In line with this interference deficit hypothesis, Chiappe, Hasher, and Siegel (2000) showed that less-skilled readers in a mixed aged sample (6-49 years old) made more intrusion errors in a working memory (listening span) task than skilled readers. Also, poor interference control in children has been related to better memory for irrelevant information and worse memory for relevant information from a text, and to difficulties in forgetting outdated, irrelevant information relative to children with good interference control (Cain, 2006; de Beni & Palladino, 2000). Finally, poor problem-solvers have difficulties in remembering relevant information in arithmetic word problems and ignoring irrelevant information (Passolunghi & Siegel, 2001). For instance, the irrelevant information could be the visual properties of a stimulus or if the problem is presented in a misleading way with regard to the correct interpretation and solution (e.g., Piaget's conservation task; Dempster & Corkill, 1999).

It is not only specific tasks that can be demanding for a child in a school environment and require interference control skills. When engaging in learning in a classroom, the child is often required to selectively attend to some source of information (e.g., the teacher, a text, or a math problem) while ignoring other information (e.g., other children talking, the thought of what to do after school, or more interesting parts of a book that the child is not supposed to read at the moment). Individuals with poor interference control have been shown to have difficulties with this (Dempster & Corkill, 1999). Even though teachers are aware of the importance of minimising misleading

or irrelevant information in learning tasks (Dempster & Corkill, 1999), they will probably attend more to this during the early school ages. Later on, the children may be expected to handle this more independently. But it is not only the demand of higher independence that increases the burden on handling misleading and conflicting situations for the child. Throughout elementary school, the information to be learned becomes more complex and higher demands are put on the child to sort out relevant information from irrelevant information. An assumption of the present thesis is that these changing conditions increase the demands on the child's interference control skills throughout elementary school.

The important role of interference control in academic achievement and in the development of good academic skills, such as math and language skills, have been supported in both cross-sectional (e.g., Espy et al., 2004; Lan et al., 2011; Thorell, 2007) and short-term longitudinal designs (e.g., Blair & Razza, 2007; Fuhs & Day, 2011; Matthews, Ponitz, & Morrison, 2009; Ponitz, McClelland, Matthews, & Morrison, 2009). However, most of these studies did not measure the aspect of interference control that includes switching between performing a prepotent response and withholding or acting counter to the prepotent response. Further, some studies have also yielded mixed findings. For example, Bull and Scerif (2001) found that for 7-year old children, high performance on a Stroop task using quantity and number was correlated with math achievement, whereas performance on a color-word Stroop task was unrelated to math achievement. None of these interference tasks included a switching component. In addition, this study showed that working memory but not interference control predicted math skills when both interference tasks were included as predictors. Further, Toll, van der Ven, Kroesbergen, and van Luit (2011) found that only one of three interference control tasks predicted math learning disabilities in 6-year old children. The task that predicted math learning disabilities had no demands on the child to switch between performing and acting counter to a prepotent response (as was the case in one of the other interference control tasks). Conversely, van der Sluis, de Jong, and van der Leij (2004), investigated older children in grade 4 to 5 and found that arithmetic disabled children compared to controls did not have problems on tasks requiring interference control (without a switching component) or shifting, but they showed deficits on a task requiring both inhibition and shifting. Similarly, although academic achievement was not investigated, Riggs, Blair, and Greenberg (2003) found that interference control at age 8 predicted decreased levels of internalizing and externalizing problem behaviors over a two-year period. In contrast, interference control did not predict concurrent internalizing and externalizing problem behaviors. An important hypothesis emerged from Riggs et al's study. They suggested that there is a developmental lag between the acquisition of the interference control capacities as measured in the lab and the ability to use these capacities in real life settings. In relation to academic

achievement, the idea about a developmental lag may be even truer for more complex interference control (i.e., has working memory and switching demands), which may take longer for the child to integrate into behaviors in for example school. One important aspect to remember is that in the lab, the child is most often told exactly what to do and s/he tries to perform to the best of her/his ability. In a real life setting, the information from the environment signaling the need for interference control is far less obvious.

As for attention skills in relation to academic achievement, few longitudinal studies stretching over more than a year have investigated the contribution of interference control in early childhood to later academic achievement (but see Bull et al., 2008). Moreover, as is the case with most (but not all) studies investigating the link between self-regulation and academic achievement, few studies have used a latent variable approach, with the advantage of taking measurement errors into account (Bollen, 1989) when investigating these processes. In Study II, a latent variable approach was used to study interference control in relation to academic achievement.

Hot Self-Regulation in School

The school environment put many demands on the students. The student is expected to be able to switch between different tasks that represent very different forms of conceptual understanding. Furthermore, for a child to function well in school it is important that s/he can focus long enough to complete a task and not be disturbed by distractions, and to be able to resume a task after a short loss of concentration (NICHD, 2003). These are all self-regulatory demands. One basic form of self-regulation involves the problem of delaying gratification of an immediate reward for a later reward, as individuals tend to choose a sooner reward instead of a later, even though most know that such a choice is not the best option (Hall, 2003).

Hot self-regulation in general and delay of gratification in particular has been less investigated in relation to early school achievement than cool self-regulation. Both interference control and delay of gratification are involved in the regulation of off-task behavior in school and during schoolwork. Interference control is related to the ability to selectively attend to only the relevant sources of information, to ignore other irrelevant sources of information, and to delete distracting and task irrelevant thoughts from working memory. In contrast, delay of gratification is related to the ability to postpone the possibility of immediate reward for the sake of a later reward. For instance, when a child is doing homework that s/he finds less amusing or interesting and s/he hears friends playing outside, delay of gratification involves the skills or strategies directed to the control of behavior to not succumb to the temptation to stop doing homework and instead go out to play with friends. As was the case with interference control, the ability to delay

gratification should be especially important in later school years when more homework is assigned, demanding the child to work on assignments independently in an environment with other, perhaps more attractive stimuli. In addition, later on in elementary school, teachers may expect children to regulate their own impulses and desires at school, which may be particularly difficult for children with difficulties to delay gratification (Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009).

When investigating the hot forms of self-regulation during the early school years, studies usually do not find a relation to academic achievement (Brock et al., 2009; Thorell, 2007; Willoughby, Kupersmidt, Voegler-Lee, & Bryant, 2011). Sonuga-Barke (2002) suggested that since many children with deficits in hot forms of self-regulation have intact cognitive (i.e., cool) control functions, they have the ability to adapt to the constraints and difficulties that delay aversion and problems with delay of gratification impose on them. On the other hand, children with deficits in cool self-regulatory functions will not have this possibility to compensate and adapt to handle these constraints, because the very skills that are needed to do this are the skills that they have problems with. This is exactly what is found in studies investigating both hot and cool forms of self-regulation in the same study (Brock et al., 2009; Thorell, 2007; Willoughby et al., 2011). In one of the few longitudinal studies, Brock et al. (2009) found that cool but not hot self-regulation predicted growth in math skills, but not literacy skills, during kindergarten. However, the three studies cited above only investigated academic skills and achievement during preschool and kindergarten. Assuming there is a delayed effect of delay of gratification on school achievement, a relation would not be expected in early childhood. To conclude, cool self-regulation would be expected to contribute to academic achievement early on. In contrast, for hot self-regulation, and especially for delay of gratification, a relation would be expected to emerge later on in elementary school. This was tested in Study I.

Task Persistence in School

Up until now, the presented research on the importance of self-regulation to academic achievement has mainly dealt with how different forms of self-regulatory skills intervene in ongoing task behavior to promote successful task completion. However, when trying to accomplish some task such as solving a difficult math problem (without looking at the solution in the back of the book) or understanding a difficult text, such an effort may result in frustration and an inclination to give up too early. One skill or trait involved in dealing with such difficulties is persistence, which in the present thesis is labelled more specifically as task persistence. Few recent studies have investigated the role of task persistence in academic achievement. Martin and

colleagues (1983) found that first-grade children with higher persistence compared to children with lower persistence (persistence was rated by the children's teachers) had better reading and math skills, controlling for reactive aspects of temperament such as distractibility and activity level. Higher persistence was also related to classroom behaviors such as less inappropriate gross-motor behavior, constructive self-directed activity, and less peer-interaction during class (observational ratings). Further, in a meta-analysis, Poropat (2009) found that the higher-order trait of conscientiousness was as strongly linked to academic achievement as intelligence. Task persistence has also been related to undergraduates' academic achievement (Dubey, 1982; Goldman, Hudson, & Daharsh, 1973). However, there is a lack of longitudinal research on the contribution of task persistence to school achievement during middle and late compulsory school (in the Swedish school system; ages 11-16). This period is seen as critical for children's future adjustment and attainment within education and work (e.g., Clausen, 1991).

The Role of Self-Regulation in Educational and Occupational Attainment

Between fifth and seventh grade, children start to think about how their interests and abilities are related to future work opportunities (Hartung, Porfeli, & Vondracek, 2005). This is in part related to the cognitive and emotional development during this period, which is characterized by an increased capacity for complex cognitive thinking and increased self-awareness (Damon & Hart, 1982; Demetriou, 2003; Fischer, 1980). Further, the educational and occupational systems in Western countries are often based on a cumulative process in which each successive step depends on earlier achievement. Therefore, adolescence is often claimed to be a period critical for later educational and occupational choices and attainment (Caspi, 2002; Clausen, 1991; Gottfredson, 1981; Hogan & Astone, 1986; Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007; Shiner & Caspi, 2003). As stated by Clausen (1991), individuals showing higher competence early in life would get a head start in comparison to those showing lower competence early in life. Pulkkinen and colleagues have described such a mechanism with regard to the effects on later adaptation of childhood behavioral problems (Dubow, Huesmann, Boxer, Kokko, & Pulkkinen, 2006; Pulkkinen, 1996). They suggested that behavior problems in childhood accumulate through life in interaction with the social environment and impair subsequent social adjustment. For instance, low academic achievement is suggested to impair later educational attainment, which in turn affects later occupational attainment. Such a mechanism suggests that the influence of many childhood problem behaviors on later occupational attainment is expected to be mediated by educational attainment.

As expected from a cumulative process in which later educational and occupational attainment depend on earlier achievement, several factors in childhood and adolescence predict later attainment, such as academic achievement (Entwistle, Alexander, & Olson, 2005), low control (Caspi, Elder, & Bem, 1987), planful competence (Clausen, 1991), self-concept (Gottfredson, 1981), aggressive behavior (Dubow et al., 2006), educational aspirations, general mental ability (Hauser, Tsai, & Sewell, 1983), self-efficacy (Lent, Brown, & Hackett, 1994), and conscientiousness (Judge et al., 1999; Roberts et al., 2007). Several of these factors have indeed been included in

models of educational and occupational attainment. In the Wisconsin model, educational and occupational attainment are viewed as a function of parental SES, cognitive abilities, academic performance, occupational and educational aspirations, and the role of significant others in childhood (Haller & Portes, 1973; Hauser et al., 1983; Sewell, Haller, & Portes, 1969). Other models include additional factors such as self-efficacy (Lent et al., 1994) and perceived social space (Gottfredson, 1981) to explain later attainment.

Even though skill development and other factors during adolescence have been claimed to impact later attainment, relatively little is known about additional factors that may influence attainment. For instance, individuals with similar background characteristics (e.g., years of education, work experience, and parental socioeconomic status) may have quite different earnings. But the explanatory power of these well known predictors is at most modest: these predictors explain approximately one fifth to one third of the variance in earnings in the United States, and much of the variance is to be explained even when including intelligence (Bowles et al., 2001).

For the present thesis, it is important to note that few models explicitly address self-regulation as a general factor that influences later attainment (for an exception, see Clausen, 1991). In Gottfredson's (1981) model, self-regulation, or more specifically persistence, is implicit as this ability is assumed to influence a child's perception (self-concept) of being able to persist in reaching goals. This in turn influences the educational and occupational choices that are perceived as realistic (social space). That is, given same social background, intellectual ability, and gender, a child with higher perceived (and actual) ability to persist in reaching a goal will be able to aim higher and pursue more difficult goals. In the present thesis, the role of a child's ability in early adolescence to persist on a task was investigated in relation to later educational and occupational attainment (Study III).

In most of the existing models, three basic features during childhood and adolescence seem of particular importance for later educational and occupational attainment. First, and based on the cumulative system of attainment, a child needs certain certificates or proof of her/his ability (e.g., good grades, to have taken certain courses) to be able to access certain educational and occupational areas. Second, a certain level of competence is needed (e.g., good enough intellectual abilities or domain specific knowledge) to get these certificates and to handle the demands to achieve a certain level of attainment (e.g., a university degree). Third, even if a child fulfills the first two criteria, this is of little help if the individual lacks motivation to pursue career goals or does not believe that it is possible or within the own competence range (this is related to for instance self-efficacy, self-concept, and perceived social space in existing models). What I would like to add to this list of basic features relevant for educational and occupational attainment is the individual's ability to persist when faced with obstacles and frustration along the way in order to attain these goals.

The research described above has mainly focused on *selection processes*, that is, factors directing a child to choose one alternative over the other. For example, low grades may force a child to choose one direction over the other, or social background factors or gender stereotypes steer a child to follow a certain path. In addition to such person-environment fit selection mechanisms other processes may be involved. Shiner and Caspi (2003) describes two additional processes: (1) *recruitment effects*, which refer to the tendency that individuals are recruited into certain paths like an education or a job based on their personality characteristics; (2) *deselection pressure*, which refers to the tendency of individuals to withdraw from settings (e.g., a job or a educational program) that pose a mismatch between the demands of the situation and the personality of the individual.

In adulthood, the link between the personality construct conscientiousness (which includes aspects of self-regulation such as persistence) and job performance is well established (Barrick & Mount, 1991; Judge et al., 1999; for reviews, see Barrick, Mount, & Judge, 2001; Roberts et al., 2007). Also, studies investigating this relation have mainly used broad measures of personality or temperament, which makes it difficult to discern the specific role of different aspects of self-regulation in relation to educational and occupational attainment. For instance, when controlling for general intelligence, conscientiousness in adolescence has been found to predict occupational status (middle adulthood) but not income (late adulthood) (Judge et al., 1999). Further, when investigating the childhood traits of mastery motivation and academic conscientiousness at age 10 in relation to educational and occupational attainment at age 30, both mastery motivation and academic conscientiousness were found to predict higher academic achievement and work competence, although only the relation to academic achievement remained significant after IQ was controlled for (Shiner, Masten, & Roberts, 2003). Finally, Moffitt and colleagues (2010) investigated a construct that they labeled self-control, which was a composite of measures collected at ages 3, 5, 7, 9, and 11, and found that self-control predicted later socioeconomic status and income at age 32. The composite measure of self-control consisted of teachers', parents', children's, and observers' reports and laboratory measures. Importantly, the composite included measures of inattention, lack of persistence, hyperactivity, impulsive aggression, impulsivity, and lab measures of cognitive and motor tasks. Thus, this construct was rather a measure of overall adaptation and easy versus difficult temperament than of self-control, thus making it difficult to disentangle which aspects that indeed predicted attainment.

Finally, it is important to take into account gender differences, especially when investigating occupational attainment. Hartung et al. (2005) stated: "The predominant finding is that boys aspire and expect to pursue male dominated occupations and girls aspire and expect to pursue female dominated occupations" (p. 396). Already preadolescent girls, when compared

with boys, aspire to a more restricted range of occupations (McMahon & Patton, 1997). Furthermore, boys tend to assign higher value on having a high income and they tend to be more singular oriented towards work and career, whereas girls tend to focus on career, family, and other social roles (Hartung et al., 2005). One consequence of this may be that while boys view work as a life career, girls might see it as a transitory activity between school and marriage/motherhood (Hartung et al., 2005). Gender differences are also seen in the Swedish labor market statistics (I refer to statistics from Sweden because Study III was based on a Swedish sample); fewer women than men attain high positions, women earn less than men, and women tend to get less pay for equal work (SCB, 2008).

Method

The three studies in the present thesis were based on longitudinal designs and used observational data. The strength with this design is that the same individuals are assessed over time which allows the study of the impact of certain phenomena at one time point on some other phenomena at a later time point at the individual level. However, as the studies were based on observational data, claims on causality are speculative.

Samples

Two different samples were used. Study I and II were based on a US sample from a longitudinal study on early pathways to school-age conduct problems (Olson, Sameroff, Lopez, Kerr, & Wellman, 2005). In this study, 241 children with diverse levels of behavioral adjustment were recruited at age 3. The children were again assessed at age 6 ($N = 213$) and at age 10 ($N = 197$). A large battery of measures was collected from the children and their parents. Attrition was not selectively based on comparisons of major sociodemographic or study characteristics.

Study III was based on a Swedish sample from the longitudinal research program Individual Development and Adaptation (IDA; Bergman, 2000; Magnusson, 1988). In IDA, an entire school-grade cohort of approximately 1,000 children in the middle-size town of Örebro was followed to adult age, starting in 1965 at age 10. Data from age 10, 13, 16, 43 (women)/47 (men) were used in this study. The dropout rate has been below 5% at school age and somewhat higher in adult age (11% at age 43 for the women and 18% for the men at age 47; see Bergman, 2000; Trost & Bergman, 2004). Attrition was not selectively based on comparisons of major sociodemographic or study characteristics except for the men for which nonparticipants had somewhat lower grades and intellectual ability in childhood compared to participants.

Measures

In Table 1, measures used in the three studies are presented. It is indicated in which study/studies the specific variable was used and whether the variable was from a questionnaire or a laboratory test. The specific test, including its reference, is also indicated. For questionnaire measures, a sample item is given, and for laboratory measures, a short description of the procedure.

Table 1. Overview of variables used in the present thesis.

Variables	Age	Measurement	Description	Example item	Reference
Study I					
Intellectual ability	3	Composite measure of the Vocabulary & Block Design subtests from the WPPSI-R.			Wechsler (1989)
SES	3	Composite of parents' occupational status & educational level.			Hollingshead (1975)
Delay of gratification	3	Composite of the Lab Gift task & the Tower task.	Lab Gift task: The child was asked not to look while the experimenter wraps a surprise gift. Tower task: The child was asked to take turns with the examiner while building a block tower.		Kochanska et al. (1996)
Task focus	3	An adapted version of the Block Design task from the WISC-III.	The child's ability to focus on a task was assessed in a mother-child dyad task requiring of the child to copy small geometric designs.		Hyein (2009)
Impulsivity/hyperactivity	3	Composite of the Impulsivity & Hyperactivity subscales of the CBQ: Maternal ratings.		"Usually rushes into an activity without thinking about it."	Ahadi et al. (1993)
Anger/frustration	3	Maternal ratings on the Anger/Frustration subscale of the CBQ.		"Has temper tantrums when s/he doesn't get what s/he wants."	Ahadi et al. (1993)

Table 1. (continued)

Variables	Age	Measurement	Description	Example item	Reference
Fear	3	Maternal ratings on the Fear subscale of the CBQ.		"Is afraid of loud noises."	Ahadi et al. (1993)
Math achievement	6	Teacher ratings using the TRF questionnaire.			Achenbach (2001)
Math achievement	10	Teacher ratings using the TRF questionnaire.			Achenbach (2001)
Language achievement	10	Teacher ratings using the TRF questionnaire.			Achenbach (2001)
Study II					
Intellectual ability	6	See Study I			
SES		See Study I			
Interference control	6	The Simon Says task & the Red-Green Signs task.	<p>Simon Says: The child was instructed to follow the examiner's commands and behavior (e.g., "touch your head") only when it was preceded by the phrase "Simon says" and otherwise be still.</p> <p>Red-Green Signs: When the examiner lifted a green sign the child was instructed to lift the same arm as the examiner and when the examiner lifted a red sign the child was instructed to lift the opposite arm.</p>		Kochanska et al. (1997)

Table 1. (continued)

Variables	Age	Measurement	Description	Example item	Reference
Attention skills	6	Maternal ratings on the Attention focusing subscale of the CBQ.		"Has trouble concentrating when listening to a story."	Ahadi et al. (1993)
Impulsivity/hyperactivity	6	See Study I			
Math achievement	6	See Study I			
Math achievement	10	See Study I			
Language achievement	10	See Study I			
Study III					
Intellectual ability	13	Composite of the verbal, logical-inductive, and spatial subtests from the Swedish DAA test.			Härnqvist (1962)
SES	13	Composite of parents' self-rating of educational attainment & income.			Magnusson (1988)
Task persistence	13	Teacher ratings on a single item scale.		See Study III, method section.	Magnusson (1988)
Educational aspirations	13	Self-ratings from a student questionnaire using a single item scale.		"For how long do you see yourself continuing with your studies after compulsory school?"	Magnusson (1988)
School interest	13	Self-ratings from a student questionnaire. Index formed by five items.		"Do you find the lectures interesting and varied?"	Magnusson (1988)

Table 1. (continued)

Variables	Age	Measurement	Description	Example item	Reference
Grade point average	13	Composite of grades in Swedish and Math.			Magnusson (1988)
Grade point average	16	Composite of grades in Swedish and Physics.			Magnusson (1988)
Educational attainment	43/47	Data collected by interview.		13-point scale: 1 indicated <i>not finishing compulsory school</i> and 13 indicated <i>having attained a doctoral degree</i>	Bergman (2000), Trost and Bergman (2004)
Income	43/47	Data collected by interview.			
Occupational level	43/47	Data collected by interview.	Swedish Standard Classification of Occupations (SSYK)		SCB (1998)

Statistical Analyses

The main statistical analytic tools used in the studies were different forms of linear regression analysis (Study III) and structural equation modeling (Study I and II). In regression analysis, only one outcome variable can be predicted, even though several predictors can be used (Tabachnick & Fidell, 1996). If several outcome variables are to be analyzed, it is possible to perform several separate regressions or to use some structural equation modeling (SEM) technique (Bollen, 1989; Kline, 2005). One such SEM technique is path analysis, which was used in Study I. In path analysis, several outcomes can be predicted at the same time, but each construct is measured by one indicator (an indicator can also be an index). In Study II, SEM including one latent variable was used (interference control measured by two indicators). If a construct has been measured with multiple indicators, the construct can be estimated as a latent variable. This is an advantage, as measurement error is taken into account (Bollen, 1989).

In Study I and II, mediation was investigated. Mediation refers to the idea that a variable at time 1 affect an outcome at a later time point via a third variable (Baron & Kenny, 1986). Specifically, Study I investigated if the effect of task focus at age 3 on math and language achievement at age 10 was mediated via its influence on math achievement at age 6. In practice, this indicates that the early advantage in math achievement for children with high task focus would persist (be constant) through elementary school. In Study II, a similar mediation model was tested but with attention skills measured at age 6, that is, at the same time as math achievement was obtained, making this a less strong model to test for mediation.

Control Variables

As described earlier, there are several known factors that influence academic achievement as well as later educational and occupational attainment. The most commonly investigated are parents' socioeconomic status (Sirin, 2005), intelligence (Hess et al., 1984; Strenze, 2006), and prior academic achievement (Alexander & Entwisle, 1998; Duncan et al., 2007; Entwisle et al., 2005). Further, all these factors are related to individual differences in self-regulation (Fuhs & Day, 2011; Schweizer, Moosbrugger, & Goldhammer, 2005; Swanson, 2008; Zelazo et al., 2008). Therefore, in order to claim that self-regulation during childhood and adolescence has a special status in explaining educational and occupational outcomes, these factors should as far as possible be controlled for. In addition to these factors, control variables

relevant to specific aspects of self-regulation were included. In Study I, investigating the contribution of hot (i.e., delay of gratification) and cool (i.e., task focus) self-regulation in preschool in relation to later academic achievement, it was important to control for aspects of the child's reactive temperament. Especially impulsivity/hyperactivity is related to hot forms of self-regulation, but less so to cool forms (e.g., Thorell, 2007; Willoughby et al., 2011). In Study II, when investigating the role of interference control in kindergarten, attention skills were included as a control variable, because of the fundamental role of attention control skills in self-regulation (Ridderinkhof & van der Molen, 1997; Unsworth et al., 2010). Furthermore, good attention skills have proven to be a strong predictor of academic achievement (e.g., Duncan et al., 2007; Romano et al., 2010). Finally, in Study III that focused on task persistence at age 13 in relation to both academic achievement and later educational and occupational attainment, the student's educational aspirations and interest in schoolwork were included as control variables. These variables were included in an attempt to not conflate the measure of task persistence with differences in motivation, or that one student works harder on tasks because s/he finds them more interesting than do other students.

Summary of Studies

Study I – The Contribution of Hot and Cool Self-Regulation in Early Childhood to Later Academic Achievement

Background and Objectives

A broad distinction has been made between cool (i.e., cognitive) and hot (i.e., emotional/motivational) forms of self-regulation (e.g., Zelazo & Müller, 2002). Further, it has been suggested that during childhood, cool self-regulation should be important for handling the demands of school and hot self-regulation would be related to emotional and social adjustment (Brock et al., 2009; Duncan et al., 2007). However, studies that have investigated the suggested dissociable relation between cool and hot forms of self-regulation and academic achievement have focused on children in preschool and kindergarten (e.g., Brock et al., 2009; Willoughby et al., 2011). With the increasing demands during elementary school for children to become increasingly more independent learners, it might be the case that hot forms of self-regulation become important for academic achievement later on during elementary school.

The aim of the first study was to investigate the relation between delay of gratification (hot) and task focus (cool) at age 3 in relation to academic achievement at age 6 and age 10, controlling for reactive temperament (e.g., impulsivity/hyperactivity and anger/frustration) and important background factors. It was expected that task focus would contribute to academic achievement (math) already at age 6, but that delay of gratification would show a delayed effect and only contribute to academic achievement (math and language) at age 10. Further, the expected early advantage for children with higher task focus in math achievement was expected to persist from kindergarten into elementary school (cf. Bull et al., 2008). Therefore, the effect of task focus on academic achievement at age 10 would be indirect via academic achievement in kindergarten.

Methods

The sample consisted of 235 children from the United States, participating in a longitudinal study on early pathways to school-age conduct problems (Olson et al., 2005). Laboratory tasks were used to measure task focus and delay of gratification. Different teachers rated academic achievement at age 6 (math achievement) and at age 10 (math and language achievement). Missing data analyses revealed no differences in intellectual ability, SES, task focus, or delay of gratification at age 3 between children with and without ratings in math and language achievement at age 6 and 10. It should be pointed out that although language achievement data were available at age 6, this variable was only included in a control analysis because too much data were missing. To control for individual differences in reactive temperament, measures of impulsivity/hyperactivity, anger/frustration, and fear rated by mothers were included as control variables (fear was excluded from the main analyses because of low correlations with main variables). Intellectual ability and parents' socioeconomic status were also controlled for. For the main analysis, path analysis was used to be able to analyze all three time points in the same model and to use math achievement at age 6 as both an outcome and as a predictor of age 10 achievement.

Results and Conclusions

In line with the hypothesis that higher task focus contributes to better academic achievement already in kindergarten and that this head start would persist through elementary school, task focus was a positive predictor of math achievement at age 6, controlling for parents' SES, intellectual ability, delay of gratification, and reactive temperament, and had an indirect effect on math achievement at age 10 (but not on language achievement) via its influence on math achievement at age 6.

In the same model, better ability to delay gratification uniquely contributed to higher language achievement at age 10 but not to math achievement. In line with previous research (e.g., Thorell, 2007), delay of gratification did not predict math achievement at age 6. In part, this supports the idea that the ability to regulate motivation and impulses becomes salient to achievement as children reach an age when they are expected to work independently on academic tasks. Further, an explanation of the unique association between delay of gratification and language achievement might be that the ability to delay gratification is often dependent upon verbal strategies for successful execution (Mischel et al., 1989). Finally, in support of the division between cool and hot forms of self-regulation, delay of gratification but not task focus was related to impulsivity/hyperactivity.

Study II – Complex Interference Control in Kindergarten and Concurrent and Later Academic Achievement

Background and Objectives

Together with working memory, individual differences in interference or inhibitory control are important predictors of academic achievement in kindergarten and elementary school. However, few studies have investigated this using a longitudinal design stretching over longer periods than a year. Further, most studies have investigated simpler forms of inhibitory control or a mixture of hot and cool forms of inhibitory control. Finally, few studies have used a latent variable approach to account for measurement error when studying the relation between interference control and academic achievement.

Two basic assumptions of the present thesis is that throughout elementary school, a child will experience increasing demands in handling complex and conflicting information and a decrease in direct support from teachers in structuring the learning environment (Brock et al., 2009; Dempster & Corkill, 1999). Further, a possible developmental lag has been described between the acquisition of complex interference control and the incorporation of these skills in a school setting.

Study II aimed at investigating the contribution of complex interference control (i.e., using tasks that included both working memory demands and a switching component) at age 6 to concurrent and later academic achievement at age 10. For this purpose, a latent variable approach was used. It was expected that interference control would show a stronger relation with academic achievement at age 10 than at age 6. Because of the fundamental role of attention in interference control, attention skills were included in the study as a control variable and as a predictor of academic achievement. Including attention skills in the study allowed for the replication of earlier findings supporting the importance of good attention skills for successful academic achievement, while controlling for interference control (e.g., Duncan et al., 2007). Attention skills were expected to be related to academic achievement at age 6. Further, along with the reasoning in Study I, an indirect effect of attention skills at age 6 on math and language achievement at age 10 via math achievement at age 6 was expected.

Methods

The sample consisted of 213 children out of a original sample of 241 from the United States, participating in a longitudinal study on early pathways to school-age conduct problems (Olson et al., 2005). The two laboratory tasks

that were used to measure interference control were the Simon Says task and the Red-Green Signs task. Different teachers rated academic achievement at age 6 (math achievement) and at age 10 (math and language achievement), and mothers rated children's attention skills. Missing data analyses revealed no differences in intellectual ability, interference control tasks, or attention skills at age 6 between children with and without ratings in math and language achievement at age 6 and 10. It should be pointed out that although language achievement data were available at age 6, this variable was not included in the analyses because too much data were missing. To control for individual differences in reactive temperament, measures of impulsivity/hyperactivity rated by the mothers were included. Further, intellectual ability and parents' socioeconomic status were controlled for. The main analysis consisted of structural equation modeling with interference control estimated as a latent factor. All variables were included in the main model at the same time, allowing the estimation of each variable's unique effect. In a second model, the contribution of attention skills at age 6 for academic achievement was investigated without interference control included in the model.

Results and Conclusions

In line with expectations, higher interference control uniquely predicted higher academic achievement at age 10 but not at age 6, controlling for parents' SES, intellectual ability, and impulsivity/hyperactivity. Further, higher attention skills uniquely predicted better academic achievement at age 6 and had indirect effects on achievement at age 10. When interference control was excluded from the model, attention skills had a direct positive effect on later language achievement, but not on math achievement. These results support the notion of increasing demands of complex interference control skills during elementary school to handle schoolwork. The results also support the importance of attention skills early on in school, giving children with good attention skills a headstart that seems to persist into late elementary school. The results further underscore the importance of controlling for other self-regulatory skills when estimating the unique contribution of attention skills in relation to academic achievement.

Study III – The Role of Task Persistence in Young Adolescence for Successful Educational and Occupational Attainment in Middle Adulthood

Background and Objectives

Even if previous research has shown that a number of important factors during childhood and adolescence contribute to later educational and occupational attainment in adulthood – foremost school grades, intelligence, and socioeconomic status - these factors only explain between one fifth to one third of the variance in individual differences in for example earnings. This means that other factors during this period contribute to later attainment. In this study, we suggest that one crucial factor is the capacity to persist on a task despite difficulties and feelings of mental effort and frustration, and that this ability is important for achievement in early adolescence and continue to be important throughout the educational system and in working life.

The aim of this study was to investigate the contribution of task persistence to academic achievement in adolescence and for later educational and occupational attainment in adulthood. Educational aspirations, interest in schoolwork, school grades, and intellectual ability were included as control variables. Also, because of major gender differences in the Swedish labor market, potential gender differences were investigated.

Methods

Data came from the longitudinal research program Individual Development and Adaptation (IDA; Bergman, 2000; Magnusson, 1988). The sample consisted of approximately 1000 individuals all living in the middle-sized town of Örebro in Sweden at the time of data collection. Data used in the present study were mainly from age 13, 16 and age 43 (women)/age 47 (men). Teachers rated children's task persistence, and academic achievement was measured by school grades. In adulthood, outcomes were educational attainment, attained occupational level, and income. To investigate the contribution of task persistence to school achievement at age 16, multiple hierarchical regression was used. When controlling for previous grades at age 13, the contribution of task persistence on change in grades were investigated. Further, to investigate whether task persistence explained later educational and occupational attainment, multiple hierarchical regression and ordinal regression were used. When predicting income and occupational level, educational attainment was also included as a control variable. This allowed investigating whether educational attainment functioned as a mediator between task persistence and occupational attainment. To explore potential gender differences, the interaction between task persistence and gender were

investigated in each model. If a significant interaction term was found, the analysis was split between the genders.

Results and Conclusions

The results showed that higher task persistence uniquely predicted a positive change in academic achievement between age 13 and 16 over and above intellectual ability and parents' SES. Further, higher task persistence uniquely predicted higher educational attainment together with all other predictors, except for interest for schoolwork.

In analyses of occupational level and income, there were significant interactions between task persistence and gender and therefore the analyses were performed separately for women and men. For men but not for women, higher task persistence uniquely predicted higher income and attained occupational level and these relations were not mediated via educational attainment. For the women, including all predictors, only educational attainment predicted later income and occupational level. Hence, in line with expectations, task persistence had an impact on men's occupational attainment, and this was not merely a consequence of its influence on educational attainment or caused by task persistence's relationship to factors like intellectual ability, educational aspirations and socioeconomic background.

General Discussion

Hot and Cool Self-Regulation in School

Earlier findings (e.g., Brock et al., 2009; Thorell, 2007; Willoughby et al., 2011) suggest that cool forms of self-regulatory skills (e.g., interference control, focused attention) are more important for academic achievement than self-regulatory skills in situations demanding the regulation of motivation, impulses, and desires (i.e., hot self-regulation). Further, Sonuga-Barke (2002) speculated that individuals with deficits in self-regulatory skills directed at the control of cognitive processes such as attention and interference control would be more affected in their schoolwork than individuals with deficits in the regulation of motivation and impulses, because the latter group would be able to compensate by using their intact cognitive control functions. However, a shortcoming of studies investigating cool and hot forms of self-regulation at the same time is that they typically have focused on children in preschool and kindergarten. Thus, the lack of relationship between hot self-regulation and academic achievement could be an age specific phenomena. Assuming that demands on children's ability to structure and regulate their studies increase during elementary school, it seems reasonable to expect a delayed effect of hot self-regulation relative to cool self-regulation on academic achievement. The findings from Study I were in line with this notion. Specifically, task focus (cool) predicted math achievement at age 6, and indirectly math achievement at age 10 via math achievement at age 6. In contrast, task focus did not predict language achievement at age 10. Delay of gratification (hot) predicted language achievement at age 10 but not math achievement at age 6.

To explain why delay of gratification predicted later language but not math achievement (Study I), it was suggested that the ability to delay gratification is often dependent upon verbal strategies for successful execution (Mischel et al., 1989). It is possible that good delay of gratification skills in early childhood is an early indicator of later verbal development. In line with this, individual differences in delay of gratification at age 3 correlated equally strong with performance on the Block design task as with the Vocabulary subtest, both from the WPPSI-R intelligence test (Wechsler, 1989), but at age 6, only the correlation with Vocabulary was significant. This supports a closer link to language development than to development in quantitative

skills. A second explanation is that language skills become more automatic than math skills during childhood (e.g., Blair & Razza, 2007), which may result in that less effort and attention resources would generally be engaged in language studies as compared to math studies. This, in turn, would result in an increased probability of distracting information entering into conscious awareness during language studies (see Study I for a more elaborate discussion). These distractions (e.g., thoughts about doing something more fun, such as playing a video game) have to be dealt with by the child, often demanding delay of gratification.

Following from the above reasoning is that cool functions such as attention control should show a stronger relation with performance on math problem-solving tasks than with performance on language tasks, like reading comprehension (Blair & Razza, 2007). The findings from Study I supported this, as task focus correlated with math achievement at age 10, but not language achievement. However, this was not supported by the findings in Study II since attention skills at age 6 were related to both math and language achievement at age 10. One important difference between Study I and II is that attention skills in Study II represent a much broader measure of attention than was the case in Study I, which was based on performance on a laboratory task. The mothers' ratings of attention skills in Study II included, for instance, items related to persistence.

In line with the claimed distinction between cool and hot forms of self-regulation (e.g., Zelazo & Müller, 2002) and as shown in other studies (e.g., Thorell, 2007; Willoughby et al., 2009), Study I showed that individual differences in impulsivity/hyperactivity were related to individual differences in delay of gratification but not to task focus. One interpretation of this later finding is that high impulsivity/hyperactivity is related to a highly reactive behavioral approach system (BAS), making these individuals more reward-sensitive. Consequently, they have more difficulties in regulating their behavior in a delay situation. However, the reinforcement sensitivity theory postulates three independent interacting systems controlling approach-avoidance tendencies (Corr, 2008). Hence, another possibility is that highly impulsive individuals have a hypoactive behavioral inhibition system (BIS). The role of the BIS is to resolve goal conflict between for instance BAS and FFFS. The BIS accomplishes this by increasing the negative valence of a stimulus until the approach-avoidance conflict is resolved. In the lab gift task, the reaction of the FFFS system is linked to the rule that the child is not allowed to look at the toy. Thus, a less active BIS can result in that the BAS (want to look at the present) – FFFS (fear of not doing as told) conflict is not strong enough, making individuals with weaker BIS to look at the present before the wrapping is finished. The relation may also be a result of a less reactive FFFS, leading to that the BAS controls behavior (Corr, 2008). Thus, the absence of relation between task focus and impulsivity/hyperactivity may

be related to that there are no reward stimuli present in the block task and so, the BAS may not be activated.

Interference Control and Academic Achievement

Study I and II shared the assumption that during elementary school, the demands on the child change to become more demanding and requiring more independent work. As a consequence of this, a delayed effect was expected on academic achievement of self-regulatory skills dealing with these changing demands relative to more basic self-regulatory skills which were expected to have an effect already early on (e.g., attention skills). However, the specific consequences these changes were expected to have on a child's self-regulatory ability differed between the studies. In Study I, the changing demands were mainly related to the regulation of off-task behavior and to postpone immediate gratification in favor for staying on task. In Study II, which investigated if individual differences in interference control in early elementary school predicted concurrent and later individual differences in academic achievement, a delayed effect was expected as a result of the increasing demands on the child to handle more complex information and a change towards less support from teachers helping children to focus on task relevant information and minimising conflicting and misleading information in learning tasks. Overall, this would lead to an increased demand to self-monitor these processes. In addition, the expected delayed effect was based on a second line of reasoning: the ability to perform well on (fairly complex) interference control tasks in a laboratory situation where the rules of the game are clearly stated by the experimenter and understood by the child occurs earlier than the ability to use these skills in a real life setting without clear clues in the environment signaling when to use them (i.e., real life application would show a developmental lag; Riggs et al., 2003).

It should be pointed out that a latent variable approach was used in Study II to study interference control in relation to academic achievement and an advantage with this analysis is that measurement error is taken into account (Bollen, 1989). Few studies of interference or inhibition in relation to academic achievement have used a latent variable approach, and typically, the latent factor in these studies has then consisted of both simple inhibitory control and more complex interference control measures (e.g., Brock et al., 2009; St Clair-Thompson & Gathercole, 2006; Willoughby et al., 2011). Others have used various forms of interference control, such as reward-based inhibition and response and motor inhibition (e.g., Espy et al., 2004). This makes it difficult to disentangle whether less complex forms of interference control contribute to academic achievement early on, and if more complex forms have a delayed impact on academic achievement. Moreover, it is not

clear from these studies whether reward-based inhibition and motor inhibition contribute differently to academic achievement.

In line with expectations, interference control had a delayed effect on academic achievement relative to attention skills. However, if part of this delayed effect was a result of the developmental lag described above, simpler forms of inhibitory control should contribute to academic achievement already at age 6. To test this possibility (these results are not included in Study II), the structural equation model presented in Study II was rerun, but motor control at age 6 was included as an additional variable measuring a simple form of inhibition. Motor control was measured by the draw-a-circle task (Kochanska, Murray, & Coy, 1997). In this task, the child is asked to draw a line along a circle, first at normal speed, then at fast speed, and finally as slow as possible. The final score was the difference in time between the fast and the slow trials. As expected, motor control predicted math achievement at age 6 ($\beta = .16, p < .05$) but not achievement at age 10. Hence, these results support the notion that simpler forms of inhibitory control can be implemented by a child in a school setting early on but more complex forms of inhibitory or interference control show a developmental lag with these more complex skills not contributing to school achievement until later on in elementary school. Previous studies have also found a relation between interference control and academic achievement already in kindergarten (e.g., Bull & Scerif, 2001; Matthews et al., 2009; Ponitz et al., 2009). However, in contrast to Study II, these studies did not include tasks with a switching demand, requiring of the child to switch between performing and withholding or act counter to a prepotent response. It may be the case that the increased difficulty taps a more complex form of interference control, contributing to the described developmental lag. The school curriculum in later elementary school also includes more activities demanding of the child to be able to for instance switch between different activities or to switch between different levels of understanding in comprehending a text.

Time Scale and Awareness in Self-Regulation and Interventions

This far, the discussion has mainly concerned different self-regulatory skills, such as attention control, interference control, and delay of gratification, and how they relate to different aspects of the development of good academic skills. Also, a broad separation was made between self-regulation in tasks demanding more cognitive control and regulation in tasks involving motivationally and emotionally salient stimuli or outcomes termed cool and hot self-regulation, respectively. Furthermore, it was stated in the Introduction

that self-regulation deals with voluntary control of behavior aimed at attaining a goal, which is not accomplished by reliance on automatic or habitual responses. But in real life, are all forms of self-regulation under voluntary control in the sense that individuals are fully aware of what they are doing? And can self-regulatory failure be described as a process in which individuals tried their best but failed, or are some forms of self-regulation failure happening outside the individual awareness? These are complex questions that merit speculation. Therefore, two aspects of self-regulation will be presented that have not been discussed this far, namely *time scale* and *level of awareness*. Moreover, I will discuss how training and intervention in childhood could be approached with regard to these aspects.

When trying to understand the factors that differentiate certain self-regulatory behaviors from others and how they can be trained, manipulated, or altered, I suggest that two aspects, seldom discussed in the literature, are important. The two aspects are the time scale and the level of awareness that different self-regulatory processes operate within. These two dimensions will be used to discuss the difference between delay of gratification and interference control. In a sense, delay of gratification and interference control deal with the inhibition of a prepotent response (e.g., not to eat the forbidden cookie, or to suppress strong automatic beliefs in order to take another point of view). These dimensions can be separated by the nature of the stimulus or outcome that they operate on (i.e., neutral/cognitive versus emotional/motivational). But an interference control task or inhibition task can be made “hot” by including a reward. However, even when adding a reward to an originally “cool” task, delay of gratification and interference control have important differences that may have implications for how to organize interventions to help children improving their skills. In short, I claim that the self-regulatory strategies directed towards the goal to postpone immediate gratification usually occur with a high level of awareness and during a relative long time period (from seconds to minutes).¹ It is a battle that the child tries to win and when lost or won, the child is aware about it. In line with this, the development of the ability to delay gratification has been strongly linked to the development of strategies that aim at increasing the differences between the value of future and the present reward (Mischel et al., 1989).

On the other hand, interference control, especially for children, often occurs outside our awareness. Situations involving interference control may for instance involve a child being unable to focus on relevant information in a

¹ Note the difference from delay discounting, which may be an unconscious process related to how fast the individual discount future reward value. Thus, delay discounting is part of the process to delay gratification but is not part of the actual self-regulatory process of choosing the delayed reward instead of the immediate reward in a situation where the individual experiences a *conflict* between the two goals. It is the behaviors directed to the solution of this conflict that are called self-regulation in relation to delay of gratification.

text, when irrelevant information lingers on in an active state of mind so that the child changes the topic too often, when the dwelling on information no longer relevant for the task at hand makes the child less able to attend to the information presented, or when the child fails to disregard misleading information in a math problem resulting in the child being unable to come up with a correct solution to the problem at hand. These examples describe failure in interference control (at least a possible source of failure), but often, these failures may pass unnoticed by the child. Further, these processes happen quickly, almost automatically. Dempster and Corkill (1999) asked the question whether interference control skills are under a child's strategic control, and if so, whether these skills can be trained. An additional question is: are children aware of their own interference control failures? As described in the introduction, children with poor interference control shift too often when learning new material with the consequence of a faster decline in memory for the recently learned material (Gernsbacher & Faust, 1991). Are children aware of these processes? Similarly, the inability to decontextualise thinking as a result of poor inhibitory control - as in the finding that children with poor inhibitory control have difficulties drawing the correct conclusion in logical reasoning when the correct conclusion is non-congruent with the person's belief - is this taking place as a conscious process (Handley, Capon, Beveridge, Dennis, & Evans, 2004)?

The reasoning above may have consequences for how we approach training and facilitation of these skills. Recent studies show that training children on rather specific self-regulatory skills such as working memory improves performance on the specific task, but transfer effects to other abilities such as fluid intelligence are often not found (e.g., Thorell, Lindqvist, Bergman Nutley, Bohlin, & Klingberg, 2009; for a review, see Diamond & Lee, 2011). Importantly, studies training interference or inhibitory control in children usually do not find transfer effects on non-trained but equivalent tasks and sometimes not even training effects on the practiced tasks (e.g., Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005; Thorell et al., 2009; but see Karbach & Kray, 2009, for improvement in children's interference control after task-switching training), with the exception of children starting with low levels of interference control (e.g., Tominey & McClelland, 2011). Conversely, the research program by Mischel and colleagues (1989) has shown that learning young children strategies to delay gratification is a successful endeavor. Perhaps this suggests that different strategies should be used when trying to improve children's self-regulation abilities. Self-regulatory functions operating at higher levels of awareness and over longer time spans (e.g., delay of gratification) may be more suited for learning children different strategies to cope with their behaviors. Self-regulatory functions operating at lower levels of awareness and over short time spans (e.g., acting contrary to personal beliefs in logical reasoning) may demand another intervention strategy: the goal may be to first make these processes and defi-

cits conscious to the child, and at a second stage, develop strategies to handle them.

However, there are successful intervention programs designed to improve children's self-regulatory abilities. One of these is the "Tools of the Mind" program used in the United States (Blair & Diamond, 2008; Bodrova & Leong, 2001; Diamond, Thomas, Barnett, & Monroe, 2007). This program seems to be most beneficial when it is implemented into the daily activities in the classroom, not as an add-on to the existing curriculum (Diamond & Lee, 2011). Results show that the program may improve children's self-regulation and decrease behavior problems (Barnett et al., 2008; Blair & Diamond, 2008; Diamond et al., 2007). One important part of the "Tools of the Mind" program, is scaffolding - allowing children to take active part in planning of the activities and in this way enabling them to build a supportive structure. Mark H. Bickhard (2010) also emphasizes the role of scaffolding in learning and development, especially the importance of self-scaffolding and how errors can be used in learning. He writes that:

Many of the relevant error spaces are similarly domain and sometimes even child specific. Experienced and skilled teachers have mastered significant portions of these realms of consideration, but as mentioned, this is generally in an intuitive manner. All too often, we are left with learning environments in which right answers are provided, and, perhaps, some sorts of explanations, but rarely is any attention expended on the errors that might be made and that are being made by this particular child. Too often, even good students can come away after having 'learned' a lesson with their prior misunderstandings of phenomena still intact. (Bickhard, 2010, p. 86)

Bickhard further comments on the limited capacity of teachers to have experienced these errors on their own:

Taking error and potential errors into account, especially with the potential for child specific versions of these, can be beyond what can be done in a classroom, and, across children (or adults) and across domains, likely beyond the capacities that any teacher can learn over even decades of experience. But knowledge of what kinds of errors have been historically made in a given domain, why they were decided to have been errors, and the kinds of errors made by a range of learners in that domain (which tend in part to track historical errors) can be developed and can be made part of available resources for intervention using computers. Computers provide the possibility of taking the intuitive and individualized skills of good teaching and making them available to all learners. [...]. This would not be merely the computer as massive storage and retrieval technology, but an ability on the part of the system to track assumptions and presuppositions in learners' interactions, and intervene with respect to the most important, the most incorrect, and the most troublesome of those 'learner contexts' – especially those that make the most difficulty in scaffolding the construction of more comprehensive knowledge. (Bickhard, 2010, p. 86)

Perhaps this approach could be applied to learning about self-regulation errors. Children could get feedback from computers on lapses of attention during problem solving and they could get feedback on their visual search strategies when learning text material or when analyzing a geometrical problem by using eye-tracking. Further, teachers could give feedback on the types of errors (e.g., focusing on task irrelevant information) made by the child and how the child could use strategies to alter her or his performance. The point being that feedback about self-regulatory failure could be related directly to the ongoing activity, not trained as a separate skill detached from the task at hand. This should be an important area of future research.

It should be noted that other programs focusing on teaching children broad socioemotional self-regulation strategies, such as the PATHS curriculum (Promoting Alternative Thinking Strategies, Riggs, Greenberg, Kusché, & Pentz, 2006), show transfer effects to children's basic self-regulatory skills, such as inhibitory control and verbal fluency. If such improvements in basic self-regulatory skills directly translates to improved academic skills are less clear (for a review, see Diamond & Lee, 2011).

Task Persistence in Early Adolescence and Later Attainment

Study I and II showed the importance of good self-regulatory skills already in early childhood for academic achievement in early and late elementary school. In Study III, the contribution of task persistence during early adolescence was investigated in relation to academic achievement and also in relation to educational and occupational attainment in middle adulthood. Task persistence includes both cool (e.g., task focus) and hot (e.g., to handle frustration and mental effort) aspects of self-regulation.

The results showed that task persistence predicted change in grades between sixth and ninth grade, while controlling for intellectual ability, parents' SES, educational aspirations, and interest in schoolwork. Thus, task persistence was not only important for concurrent achievement, but individuals high in task persistence also tended to increase their grades more compared to individuals with lower task persistence. In school, a student has to be able to learn new material and complete tasks that s/he does not find interesting or exciting (Dewey, 1913). Several factors can influence the student's ability to handle these demands, such as demands from parents or a strong drive for achievement. Another important factor is suggested by these results: the ability to persist on a task.

Do individual differences in task persistence during childhood and adolescence also affect later attainment? As stated in the introduction, the educational system in modern societies are often very structured and each stage

of attainment (e.g., be accepted into higher education) is often dependent on a certain level of attainment at the previous stage (e.g., getting grades that are good enough). One implication of this is that timing is important (Clausen, 1991). Individuals showing high competence already in adolescence tend to get a head-start in life compared to individuals low in competence. Even if these differences would decrease at later ages, it would be difficult (although not impossible) for individuals falling behind in the educational and occupational track to catch up (Clausen, 1991). If this would be a deterministic system with attainment at each stage more or less determining (within some restricted range) attainment on the next level, we would expect early attainment to be a strong predictor of later occupational attainment (e.g., only having a high school diploma severely restricts future occupational choices, especially in today's highly competence dependent working market). However, as described earlier, this is not the case (Bowles et al., 2001). Thus, the benefit of good self-regulatory skills during childhood and adolescence might not only affect academic achievement during this period, which in turn would affect later attainment, but may have a continuous impact on attainment throughout life. This is what was shown in Study III: task persistence in early adolescence uniquely predicted both educational attainment (men and women) and occupational attainment (men only) in adulthood.

These findings suggest that we should not only be concerned with promoting self-regulation during childhood with the purpose of improving academic skills, but we should also promote self-regulatory skills in children as a way of increasing their ability to deal with everyday demands throughout their lives. As described in Study III, other mechanisms have been suggested to explain the relation between early personality characteristics and later attainment. Shiner and Caspi (2003) described three such mechanisms: selection processes, recruitment processes, and deselection processes. Importantly, these processes are at play from early on in a child's life. For instance, all three processes are probably involved in peer selection/deselection processes (Eisenberg et al., 2004). Further, which career goals an individual perceives to be within reach depends on what the person perceives as possible and the amount of effort the person is ready to invest in reaching those goals (Gottfredson, 1981). Hence, these goals are selected/deselected partly based on the person's personality characteristics such as persistence. These processes were not studied in relation to task persistence in the present thesis but the results suggest that these processes are not only at play early on by influencing academic achievement, aspirations, and career choices, but continue to operate into middle adulthood. For instance, if individuals' select and are selected into occupations based on their personality characteristics we would expect that highly persistent individuals are more often found in high level occupations and that they also perform at a high level. This is also what is found: conscientiousness in adulthood is positively

related to job performance and occupational attainment (Barrick & Mount, 1991; Barrick et al., 2001; Judge et al., 1999; Roberts et al., 2007) indicating that the described selection and recruitment processes might be at work. A weakness with the few earlier studies investigating self-regulation during childhood and adolescence in relation to occupational attainment is that these studies used broad measures of personality or temperament traits like conscientiousness or self-control (e.g., Judge et al., 1999; Moffitt et al., 2010). Therefore, a strength with Study III was that a more narrowly defined trait or skill was investigated in relation to career development and attainment.

The different selection processes described by Shiner and Caspi (2003) mainly deals with how specific patterns of person-environment interactions emerge as a consequence of an individual's personality characteristics and how these interactions tends to reinforce these very personality characteristics. However, these processes do not explain how individual differences in personality emerge in the first place. Some of these differences are probably linked to biologically based temperament differences emerging early in life (Rothbart & Bates, 1998). In relation to individual differences in persistence, Eisenberger's (1992) theory of learned industriousness offers an additional explanation. As stated in the Introduction, the theory explains individual differences in persistence as a process that through reinforcement change the subjective aversive experience of mental effort into something linked to reward. That is, if a person invests a large amount of cognitive or physical effort into some task and is rewarded for that, the sensation of high effort turns into a secondary reinforcement that decreases the innate aversiveness of effort. Thus, the theory opens up for the possibility of changing a person's persistence by designing learning environments that reinforce high effort. Study III suggests that since task persistence in young adolescence had direct and unique effects on both later educational and occupational attainment some 30 years later, such reinforcement of persistence would have pervasive effects throughout an individual's life within several areas. To study these reinforcement processes and the selections processes described earlier in more detail would be an important next step in understanding the dynamics between self-regulation and attainment from adolescence into adulthood.

As stated above, task persistence in young adolescence was only related to later occupational attainment for the men. Several reasons for this finding are discussed in Study III. Perhaps most important are structural factors of the Swedish labor market, as fewer women than men attain high positions in working life, and women tend to get less pay for equal work (SCB, 2008). Further, gender differences in relation to vocational development are seen early on as boys for instance are more exclusively career oriented, whereas girls tend to focus on both career and family (Hartung et al., 2005; McMahon & Patton, 1997). Nieva and Gutek (1981) also suggested that social structural factors influence women's career attainment to a higher extent and

psychological factors are more influential on men's career attainment. In Study III, parents' SES only predicted later occupational attainment for women. When educational attainment was included in the regression model, it was the only significant predictor of women's later occupational attainment. On the other hand, both task persistence and educational aspirations predicted later occupational attainment for men, even when controlling for educational attainment. Hence, the model suggested by Nieva and Gutek (1981) was to some extent supported by the results of Study III.

Strengths and Limitations

The major strength of the present thesis was the use of a longitudinal design. Further, by using two different data sets, it was possible to investigate the relation between self-regulation and achievement and attainment from early on in childhood into middle adulthood, covering a period of over 40 years. It is often said that a longitudinal design provides the opportunity to investigate the relation between phenomena over time for the same individuals, although it is most often not possible to attribute causality to these relations. However, finding causal relations in the experimental manipulation sense is perhaps in many cases not a meaningful endeavor in non-experimental research (Bergman, 2009). Also, despite the many merits of experimental research, it is not clear how to design a strict experimental study investigating the dynamic relations over time between self-regulation and academic achievement. This does not mean that many current longitudinal designs could not be improved. One fruitful direction is the intense study of individuals using dynamic system principles and methods to investigate development (in relation to motor development, see Thelen & Smith, 1994; in relation to cognitive development, see van Geert, 1998). The collection of many time points makes it possible to model data using mathematical models more suited to study change than the usual models used within psychology (e.g., difference and differential equations; Luenberger, 1979). Within this type of longitudinal design, experimental manipulations could be included (e.g., how manipulation of task load and amount of distraction affects task focus) and individual differences in reaction to these manipulations could be used as variables when modeling longitudinal relations.

Another strength with the present thesis was that several forms of self-regulation were investigated, and in two of the studies, they were investigated simultaneously in the same model. This allows for the study of the unique contribution of for instance interference control and attention skills on academic achievement and also for potential developmental differences in relation to achievement. Further, all three studies included important background factors (e.g., intellectual ability) and other relevant control variables (e.g.,

impulsivity/hyperactivity in Study I and II) known to be related to the outcomes and to the specific predictors that were assessed.

A limitation was that development of self-regulation was not investigated. This would have allowed for the study of change in self-regulation in relation to change in academic achievement. A more severe limitation was that only interindividual differences were studied. Drawing conclusions to the individual level based on interindividual differences make strong assumptions on the behavior of the system (e.g., the processes under study have to be ergodic; Molenaar, 2004). This limitation emphasizes the value of intensive studies as suggested above.

Another assumption made in the present thesis was that the relevant unit of analysis is the variable, and associations should be studied as associations between variables. From an interactional perspective, Magnusson (1988) has suggested that the person should be seen as an organized whole consisting of different interrelated levels of operation (e.g., biological, cognitive, social). Each functional subsystem is defined as a pattern of interrelations between certain factors. One consequence of this view is a person-oriented approach where phenomena are studied at the level of the pattern of its constituent parts, not at the level of the different variables (Bergman & Magnusson, 1997). With respect to the present thesis, important system information may lie in the way different self-regulatory functions tend to structure together. Are there certain typical configurations of interference control, attention skills, and delay of gratification that tend to emerge (called *types*, Bergman & Magnusson, 1997), and do these typical patterns contain information at the system level that would not be found when each factor is studied in separation? This would be an important area for future research.

Furthermore, it could be speculated that the use of teacher ratings instead of achievement tests to study academic achievement would weaken the findings, because of the difficulty to correctly rate children's skills and a rater bias which may take irrelevant child characteristics into account (e.g., the child's interpersonal skills). However, the use of teacher ratings may also be viewed as a strength. According to Graziano, Reavis, Keane, and Calkins (2007), teacher ratings could provide a more comprehensive and representative sample of academic content and unique information about a child's academic behavior. Further, results from a study that included six different data sets showed that the effects of the predictors (e.g., attention skills) on teacher rated performance or direct skill assessments were about the same (Duncan et al., 2007).

Another limitation was that the US data set were based on fairly homogeneous samples in terms of socioeconomic status. Therefore, it is important to study under what other conditions the results might hold. Also, the finding of a delayed effect of delay of gratification at age 6 on language achievement should be interpreted with caution as language achievement at age 6 was not included in the model as a result of missing data. A control analysis, includ-

ing language achievement at age 6 in the path model, showed that the relation to delay of gratification was non-significant, which at least does not disconfirm the interpretation of a delayed effect (the test of this relation included 114 children). Finally, environmental influences such as parenting style, peer group, and neighborhood have strong influences on a child's life and how a child functions in school and what career a child takes on (e.g., Bronfenbrenner, 1979). In the present thesis, environmental differences were included as a rough control variable in the form of the socioeconomic status of the child's parents. Much further research is needed to understand how the interplay between the environment and the child affects self-regulation during childhood.

Concluding Remarks

The results in the present thesis suggest that different forms of self-regulatory skills during childhood and adolescence are important for successful academic achievement and later educational and occupational attainment. What can be learned from these results? A critic might say that the results are rather expected as it is reasonable to believe that well-behaved children would do better in school than do less well-behaved children. The problem with this argument is that it reduces self-regulation to behavior in accordance with social conventions. It fails to take into account the involvement of self-regulation in many more subtle processes, such as suppressing personal beliefs in the service of taking another point of view, or the use of strategies to avoid being confronted with temptations one cannot resist.

The present thesis shows that good or poor self-regulation early on in a child's life may have consequences for later academic achievement and even for occupational attainment in adulthood; consequences that cannot be explained by self-regulation's relationship to other factors known to be of importance for attainment. The results further suggest that even though reliable individual differences can be seen in tasks related to delay of gratification and interference control early on in childhood, the effects on academic achievement seem to be delayed until later on in elementary school. Moreover, attention skills proved to be important for academic achievement but individual differences in these skills could not account for the effects of delay of gratification and interference control. Together, these results imply that in relation to academic achievement, self-regulation consists of separate, although interrelated functions, each contributing in different ways to the development of academic skills. This might have implications for interventions in school: first, children's self-regulatory skills could be the actual target for interventions, and secondly, it is important to acknowledge the multidimensionality of these skills. It then follows that different interventions are probably needed to improve different skills. Furthermore, the results in the

present thesis suggest that the ability to persist on a task is a fundamental ability for successful attainment through life whether with regard to educational or occupational career.

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