Temperamental Influences on Risk-taking during Middle Childhood

Nyström, Beatrice

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Beatrice Nyström

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Abstract

This thesis concerns temperamental qualities and their influence on risk-taking behavior during middle childhood (7–11 years of age). Contemporary research generally agrees upon the notion that temperament constitutes two motivational systems, sensitive to punishment and reward respectively, together with a third system that is responsible for regulating input from the other systems. Risk-taking is generally regarded as a tendency to engage in potentially harmful or dangerous behaviors that at the same time provide opportunities for positive outcomes (Leigh, 1999). Research has been able to establish a relation between temperamental traits and risk-taking, but generally, research has focused on the influence of one temperamental system at the time. We examined the interaction effects between temperamental traits fear, drive, and activation control on risk-taking. Fear and drive represent the punishment sensitivity system and the reward system respectively, and activation control is the ability to control the reactions in these two systems. Results from our first study suggest that the joint influence of the temperamental systems is of great importance in risk-taking, and also that activation control abilities provide a good protection for children prone to risk-taking behavior. Furthermore, in our second study, we examined how children's temperamental qualities interact with incentive contexts in risky decision-making. We aimed to assess response time modulation in risk-taking, an aspect of self-regulation that has been difficult to reach with existing methods. In order to do this, we developed a new computerized instrument: The Risky Decision-Making Test (RDMT; Bengtsson, Nyström & Van De Weijer, 2016). Results suggest that incentive-related contextual factors have a strong influence on risky decision-making and that temperament modifies this influence, thereby reducing or increasing children's proneness to take risks. Lastly, we provide a psychometric evaluation of the Temperament in Middle Childhood Questionnaire (TMCQ; Simonds & Rothbart, 2004), one of the temperament questionnaires used in the other two studies. The results from our studies provide a better understanding of how temperamental qualities interact in children's risk-taking, and of how the effects of temperament on risky decision-making can be moderated. This is highly relevant information, since research suggests that effortful control abilities are possible to improve through training.

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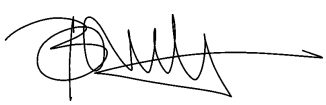
Signature  Date 02/12/2016

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To my family

Content

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List of articles

1. Nyström & Bengtsson (2016). A psychometric evaluation of the Temperament in Middle Childhood Questionnaire (TMCQ) in a Swedish sample. *Submitted manuscript.*

2. Nyström & Bengtsson (2016). Temperamental Influences on Children's Risk-taking in Decision-making: A Dual Process, Multi-Level Analysis. *Personality and Individual Differences, 89,* 177–181.

3. Bengtsson, Nyström & Van De Weijer (2016). Temperamental Qualities Moderate Incentive-related Contextual Influences on Children's Risk-taking Decisions. *Submitted manuscript.*

Abbreviations

ADHD	Attention Deficit Hyperactivity Disorder
ANOVA	Analysis of Variance
BART	Balloon Analogue Risk Task
BART-Y	Balloon Analogue Risk Task for Youth
BAS	Behavioral Activation System
BIS	Behavioral Inhibition System
CBQ	Children Behavior Questionnaire
CCT	Columbia Card Task
CFA	Confirmatory Factor Analysis
DNA	Deoxyribonucleic acid
E	Extraversion
EC	Effortful Control
EEG	Electroencephalogram
EFA	Exploratory Factor Analysis
FFFS	Fight Flight Freeze System
IGT	Iowa Gambling Task
IQ	Intelligence Quotient
JSH	Joint Subsystem Hypothesis
N	Neuroticism
NA	Negative Affectivity
PCA	Principal Component Analysis
RDMT	Risky Decision Making Test
RST	Reinforcement Sensitivity Theory
o-RST	Original Reinforcement Sensitivity Theory
r-RST	Revised Reinforcement Sensitivity Theory
RT	Reaction Time
SPSRQ	Sensitivity to Punishment, Sensitivity to Reward Questionnaire
SPSRQ-C	Sensitivity to Punishment, Sensitivity to Reward Questionnaire for Children
SSH	Separable Subsystem Hypothesis
SU	Surgency
TCI	Temperament and Character Inventory
TMCQ	Temperament in Middle Childhood Questionnaire
WM	Working memory

Abstract

This thesis concerns temperamental qualities and their influence on risk-taking behavior during middle childhood (7–11 years of age). Contemporary research generally agrees upon the notion that temperament constitutes two motivational systems, sensitive to punishment and reward respectively, together with a third system that is responsible for regulating the motivational systems. Risk-taking is generally regarded as the tendency to engage in potentially harmful or dangerous behaviors that at the same time provide opportunities for positive outcomes (Leigh, 1999). Research has been able to establish a relation between temperamental traits and risk-taking, but generally, research has focused on the influence of one temperamental system at the time.

Study 1 of this thesis provides a psychometric evaluation of the Temperament in Middle Childhood Questionnaire (TMCQ; Simonds & Rothbart, 2004), one of the temperament questionnaires used in the other two studies. We also tested the ability of the punishment and reward sensitivity factors from the r-RST, as measured by the Sensitivity to Punishment, Sensitivity to Reward Questionnaire for Children (SPSRQ-C; Colder et al., 2011), to validate the corresponding factors from the TMCQ. To our knowledge, this is the first study that uses instruments from two of the most widely recognized theories of temperament, in order to validate them against each other.

Our second study examines the interaction effects between temperamental traits fear, drive, and activation control on risk-taking. Fear and drive represent the punishment sensitivity system and the reward system respectively, and activation control is the ability to control the reactions in these two systems. Temperament was assessed using the same questionnaires as in study 1, and risk-taking was assessed using a computerized risk-taking test: the Balloon Analogue Risk Task for Youth (BART-Y; Lejuez et al., 2007). Results from this study suggest that the joint influence of the temperamental systems is of great importance in risk-taking, and also that activation control abilities provide a good protection for children prone to risk-taking behavior. This is interesting, since it provides more detailed information about which children are in the danger zone of developing maladaptive risk-taking behavior.

Lastly, our third study examines how children's temperamental qualities interact with incentive contexts in risky decision-making. We aimed to assess response time modulation in risk-taking, an aspect of self-regulation that has been difficult to reach with existing methods. In order to do this, we developed a new computerized instrument, The Risky Decision-Making Test (RDMT; Bengtsson, Nyström, & Van De Weijer, 2016). Results suggest that incentive-related contextual factors have a

strong influence on risky decision-making and that temperament modifies this influence, thereby reducing or increasing children's proneness to take risks. The findings supported predictions based on the revised Reinforcement Sensitivity Theory (r-RST; Gray & McNaughton, 2000), regarding how temperament and incentive context jointly determine behavior in risk-taking situations.

The results from our studies provide a better understanding of how temperamental qualities interact in children's risk-taking, and of how the effects of temperament on risky decision-making can be moderated. This is highly relevant information, since research suggests that effortful control abilities are possible to improve through training.

Swedish Summary

Min avhandling handlar om hur barns medfödda temperamentsegenskaper påverkar deras risktagande. I vår första studie ville vi studera psykometriska egenskaper hos det frågeformulär vi avsåg att använda i studie 2 och 3; the Temperament in Middle Childhood Questionnaire (TMCQ; Simonds & Rothbart, 2004), från Rothbart's temperamentsteori. Vi ville även validera TMCQ mot korresponderande temperamentsfaktorer från ett annat formulär; the Sensitivity to Punishment, Sensitivity to Reward Questionnaire for Children (SPSRQ-C; Colder et al., 2011), vilket härstammar från den neurobiologiska temperamentstraditionen grundad av J. A. Gray, the revised Reinforcement Sensitivity Theory (r-RST; Gray & McNaughton, 2000). Vår huvudhypotes inför studie 2 var att barns temperamentsegenskaper påverkar deras risktagandetendenser, och att det framförallt är kombinationen av de olika egenskaperna som är avgörande. Inför studie 3 antog vi att barnens vilja att ta risker, och deras svarshastighet vid beslutsfattandet, skulle påverkas av möjliga vinster och förluster. Vi antog att sambandet skulle påverkas av storleken på vinsten och förlusten samt att sambandet skulle modereras av deras temperamentsegenskaper.

Denna avhandling använder genomgående följande definition på temperament, formulerad av Derryberry och Rothbart (1997): medfödda individuella skillnader i emotionell-, motorisk- och uppmärksamhetsrelaterad reaktivitet samt förmågan att reglera dessa reaktioner (fritt översatt av undertecknad). Temperament handlar alltså om hur snabbt, hur intensivt och hur länge vi reagerar med våra känslor, vår motorik och uppmärksamhet. Enligt Rothbarts teori består vårt temperament av två motivationella system, Negative Affectivity (NA) och Surgency (SU), samt ett komplementärt system Effortful Control (EC), vars uppgift är att reglera de två motivationssystemen. NA-systemet involverar negativa affekter och har som mål att

hålla oss tillbaka i en hotfull situation. SU-systemet involverar positiva affekter och har som uppgift att få oss att närma oss olika situationer. EC handlar om självreglering och reglerar därmed de övriga två systemen. Rothbarts temperamentsteori utgör en teoretisk grund för denna avhandling tillsammans med en annan av de globalt största nutida temperamentsteorierna, the Reinforcement Sensitivity Theory (RST).

R-RST är en neurobiologisk teori som tagit avstamp i omfattande djurstudier. Den första versionen, ”the original Reinforcement Sensitivity Theory” (o-RST), lanserades 1982 av Jeffrey Allan Gray. Efter ytterligare många år av forskning, som gav upphov till revideringar av teorin, kom 2000 ”the revised Reinforcement Sensitivity Theory” (r-RST; Gray & McNaughton, 2000). Enligt r-RST reflekterar våra temperamentsegenskaper aktiviteten i två neurobiologiska motivationssystem; det defensiva systemet (BIS: Behavioral Inhibition System och FFFS: the fight-flight-freeze system) som stimulerar och reglerar undvikandebeteenden och det appetitiva systemet (BAS: Behavioral Activation System) som stimulerar och reglerar närmande beteenden (Gray & McNaughton, 2000). Det appetitiva systemet är känsligt för belöning och det defensiva systemet är känsligt för bestraffning. Personlighetsmässigt skulle man, i en given situation, antingen kunna vara en person som oftast motiveras av att bli belönad, eller en person som oftast motiveras av att undvika bestraffning. Det är viktigt att i sammanhanget betona *oftast*, eftersom vi människor i många situationer påverkas av hur eftertraktad belöningen är, eller motsvarande; hur fruktad bestraffningen är. Det är alltså osannolikt att en person alltid, i alla situationer, agerar på ett visst sätt, men på ett generellt plan styrs vi oftare av det ena eller andra systemet.

Utöver de två reaktiva motivationella system som studerats inom RST antar temperamentsforskare att det finns ett system som svarar för viljemässig kontroll av motivationella tendenser (Eisenberg, Edwards, et al., 2013; Rothbart & Bates, 2006). Även om viljemässig kontroll ännu inte accepterats av RST-traditionen som en del av vårt medfödda temperament, anses det av andra temperamentsteorier vara en av de grundläggande komponenterna.

Rothbart inkluderar viljemässig kontroll (EC), som en grundläggande komponent i sin temperamentsteori. Eftersom viljemässig kontroll och vissa andra temperamentsegenskaper utvecklas över tid (Caspi, Roberts, & Shiner, 2005; Kagan, Snidman, & Arcus, 1998) är det viktigt att ha åldersanpassade mätinstrument. I de tre studier som ligger till grund för denna avhandling användes två frågeformulär som riktade sig till barnens föräldrar för att få mått på barnens temperamentsegenskaper, the Temperament in Middle Childhood Questionnaire (TMCQ) och the Sensitivity to Punishment, Sensitivity to Reward Questionnaire for Children (SPSRQ-C), från r-RST.

Den första empiriska studien i avhandlingen undersöker egenskaper hos det temperamentsformulär, vilket sedan användes i studie 2 och 3, The Temperament i. Middle Childhood Questionnaire (TMCQ). TMCQ är ett av många formulär som härstammar från Rothbarts temperamenttradition av välvaliderade och beforskade instrument. Det har dock funnits mycket lite forskning att tillgå på just detta frågeformulär angående dess psykometriska egenskaper. Nyligen publicerades en studie av Kotelnikova, Olino, Klein, Mackrell och Hayden (2016), som var mycket kritisk till TMCQ och dess förmåga att i nuvarande format mäta temperamentsegenskaper hos barn. Kotelnikova föreslog att en stor andel av formulärets items (påståenden) skulle strykas och att resterande items borde fördelas på fyra faktorer vilka inte liknar faktorerna från Rothbarts ursprungliga analyser. Vi ville därför studera testets psykometriska egenskaper och även dess faktorstruktur utifrån de delskalor som Rothbart föreslår i testmanualen. Vi ville även validera frågeformulärets förmåga att mäta känslighet för bestraffning och belöning enligt r-RST, genom att jämföra resultaten med resultat från frågeformuläret SPSRQ-C, vilket härstammar från en annan temperamentstradition, r-RST. Till skillnad från Kotelnikova fick vi en faktorlösning som matchade Rothbarts teori på ett bra sätt då vi använde samtliga items i formuläret. Vidare visade analyserna på en god reliabilitet hos delskalorna i instrumentet, jämförbara värden med de i den amerikanska standardiseringen. Avseende validiteten kunde vi konstatera att TMCQ har en god konvergent validitet, och att det därmed har förmåga att mäta såväl närmandesystemet (styrt av belöning) som undvikandesystemet (styrt av bestraffning), mätt via jämförelser med liknande faktorer i SPSRQ-C. Mer forskning behövs dock avseende testets externa validitet.

I vår andra studie ville vi undersöka sambandet mellan temperament och risktagande hos barn i åldern 9–10 år. Det unika med vår studie är att vi kombinerade egenskaper från de tre temperamentsfaktorerna för att se hur interaktionen påverkade riskbenägenheten hos barnen, i stället för att välja ut en enskild egenskap. Risktagande mättes genom ett dataspel, the Balloon Analogue Risk Task for Youth (BART-Y; Lejuez et al., 2007). Från det appetitiva systemet valde vi egenskapen driv (drive), som enligt r-RST definieras som ”persistent pursuit of desired goals”, det vill säga ett ihållande målinriktat beteende. Från det defensiva systemet valde vi ut rädsla (fear), vilket är en reaktiv grundaffekt som finns hos alla i olika utsträckning. Till detta lades viljemässig aktiveringskontroll (activation control), en aspekt av viljemässig kontroll som innebär förmågan att fortsätta genomföra en handling trots att det finns starka tendenser att inte göra det. Resultaten från vår första studie visar tydligt att inte en ensam egenskap, eller ett unikt motivationssystem, kan förutsäga risktagande, utan det är kombinationen av egenskaper från de olika systemen som är avgörande. För de orädda barnen, som samtidigt hade höga nivåer av driv, var nivåerna av viljemässig kontroll avgörande; hade dessa barn låga nivåer av viljemässig kontroll var sannolikheten hög att hon eller han skulle vara mycket riskbenägen. Orädda barn

med ett högt driv och en god förmåga till viljemässig kontroll däremot, tog mycket få risker. Resultaten påvisar vikten av en god förmåga till viljemässig kontroll för att undvika att hamna i situationer som riskerar ha ett negativt utfall. Denna kunskap är värdefull, eftersom forskning har visat att viljemässig kontrollförmåga kan tränas upp.

I studie 3, var vi intresserade av att studera hur barn modulerar sin riskbenägenhet i olika situationer utifrån förändringar i incitament, samt hur dessa processer påverkas av temperament, vilket inte har studerats tidigare. Genom att förankra studien teoretiskt i r-RST skapade vi hypoteser om hur denna samverkan borde se ut. Vi antog att barns temperamentsegenskaper skulle påverka frekvensen i deras risktagande samt deras svarshastighet, men också att skillnaderna ökar ju mer som stod på spel. Vi använde oss av samma temperamentsformulär som i studie 1: TMCQ och SPSRQ-C. Vidare utvecklade vi ett nytt instrument för att mäta riskbenägenhet i beslutsfattande under varierande kontextuella faktorer: the Risky Decision-Making Test (RDMT; Nystrom & Bengtsson, 2016). Med kontextuella faktorer avses här hur mycket som står på spel i den aktuella situationen, det vill säga hur mycket barnet kan vinna eller förlora genom sitt val. Vi använde oss av delskalorna Impulsivitet (Impulsivity, SPSRQ-C) och Rädsla (Fear, TMCQ), som mått på det appetitiva och det defensiva systemet, samt faktorn Viljemässig kontroll (Effortful Control, TMCQ). I samstämmighet med studie 2 visar resultaten att alla tre temperamentsystemen ger sina unika bidrag till barns risktagande. De främsta resultaten från studie 3 är att incitament i miljön kraftigt påverkar riskbenägenheten hos ett barn, det vill säga att risktagande ökar i frekvens och går snabbare när det finns mer att vinna, och minskar i frekvens samt går långsammare när det finns mycket att förlora. Som förväntat modererades detta samband av barns temperament; impulsiva barn tog oftare risker, och barn med höga nivåer av rädsla tog mer sällan risker. Orädda barn fattade även mycket snabbare beslut än andra barn, i takt med att den potentiella vinsten ökade samtidigt som barn med höga nivåer av rädsla, i stället fattade långsammare beslut i takt med att den potentiella förlusten blev större. Vidare visade resultaten att en god viljemässig kontroll minskar sannolikheten att barnet ska ta risker, och bidrar till en generell kompetens i beslutsfattande: förmågan att kunna fatta övervägande korrekta, rationella och konsekventa beslut. Resultaten stöder antaganden baserade på Reinforcement Sensitivity Theory angående hur temperament och motivationella faktorer i miljön tillsammans avgör beteenden i situationer av risktagande.

Introduction

This thesis is about individual differences in temperament during middle childhood, and how they are related to risk-taking behavior. When I first started my doctoral studies in 2011, I was confronted by people in my environment with questions such as: "temperament, are researchers really still interested in that?" and "personality, isn't that topic very out-of-fashion?" Well, to some extent I guess they were right in their concerns. However, after almost five years of studying literature on temperament and personality, I've come to realize that research on temperament is not only alive and vibrant, but also wide-spread over different cultures and research areas. Personality research thus continues to fascinate and tends to be flexible and adapt to the zeitgeist. In my view, individual differences regarding temperament and personality in humans cannot be ignored; they do exist, but are not easily captured.

Contemporary temperamental research alleges that temperament is grounded in two separate systems of neural reactions, approach or avoidance impulses, and our ability to control these reactions (e.g., Eisenberg, Eggum, Sallquist, & Edward, 2013; Rothbart & Bates, 2006). Motivation is at the core of temperament; punishment or reward will motivate and direct our behavior in a specific situation of approach-avoidance. In the current thesis, reward sensitivity and approach behavior are used interchangeably to describe the same type of behaviors, and the same is true for punishment sensitivity and avoidance behavior. Our innate temperamental disposition decides the intensity, and the longevity of our reactions and also how quickly we will react. It is generally acknowledged, but not entirely scientifically established, that temperament constitutes the base for human personality (e.g., Clark, 2005; Graziano, Jensen-Campbell, & Sullivan-Logan, 1998; McCrae et al., 2000; Rothbart, 2007), complexly intertwined with continuous life-experiences.

Risk-taking has been defined as the tendency to engage in potentially harmful or dangerous behaviors that also provide opportunities for positive outcomes (Leigh, 1999), or simply choosing the option with the higher outcome variability (Figner & Weber, 2011). Hence, a wide range of behaviors qualify as risky. Many researchers in the past have regarded risk-taking behavior as a one-dimensional concept, but most contemporary researchers agree that risk-taking behavior is multi-dimensional and that individuals respond inconsistently over different risky situations. Consequently, risk-taking can take place within many different domains such as within health and

safety, ethics, recreation, finance, and gambling (Weber, Blais, & Betz, 2002). Although a majority of studies on risk-taking focuses on dangerous or detrimental risk-taking, risk-taking behavior can actually be both adaptive and maladaptive depending on context. From an evolutionary perspective, risk-taking promotes exploration of novelty and sensation seeking. Risk-taking behavior is therefore essential for human survival and progress. Delinquent and risky behaviors can be regarded as signaling functions that can enhance the individual's reputation as tough and brave, and has the potential of leveraging hierarchic positions (Ellis et al., 2012).

Aims of the Thesis

The main objective of this thesis was to investigate temperamental influences on risk-taking during middle childhood. Risk-taking has been referred to as the tendency to engage in potentially harmful or dangerous behaviors that at the same time provide opportunities for positive outcomes (Leigh, 1999). Although risk-taking is an area that has been extensively investigated during the last few decades, most research on temperament and risk-taking focuses on the direct impact of a single behavioral trait on risk-taking behavior (e.g., impulsivity or sensation seeking). In cognizance of the complexity of human temperament and behavior, we hypothesized that there ought to be more to inclined risk-taking behavior than merely the lack of self-regulation; and that risk-taking rather is regulated by several traits working together. In addition, there is strong reason to expect risk-taking to be determined by personal factors in interaction with situational factors (Figner & Weber, 2011).

The first aim of this thesis was to examine the psychometric structure of the Temperament in Middle Childhood Questionnaire (TMCQ), since this questionnaire would be used to assess temperament in study 2 and 3. Although the TMCQ is part of the large family of well-validated temperamental questionnaires from Mary K. Rothbart and her colleagues, there has been a shortage of research reports on its psychometric properties. Moreover, recently published research by Kotelnikova et al. (2016), which examined the factor structure of TMCQ, was highly critical of the questionnaire in its current format. Accordingly, there were several reasons to further examine the psychometric properties of the questionnaire. As part of this endeavor, we aimed to validate the TMCQ's ability to measure punishment and reward sensitivity. To do this, we used the Sensitivity to Punishment, Sensitivity to Reward Questionnaire for Children (SPSRQ-C; Colder et al., 2011), to validate the corresponding factors from the TMCQ. Stemming from the Reinforcement Sensitivity Theory RST tradition (Gray, 1982; Gray & McNaughton, 2000) the SPSRQ-C has received much attention in research, and was considered a good candidate for such comparative research.

The second aim of this thesis was to investigate the relative contribution of three temperamental traits on risk-taking, and also to see how they interacted with incentive-related contextual circumstances in children's approach and avoidance behavior. From a temperamental perspective we hypothesized that traits reflecting punishment and reward sensitivity systems would be contributors, and also that the ability to deliberately control behavior would influence risk-taking. While prior research has linked the temperamental traits EC, impulsivity, and fearfulness to the regulation of children's risk-taking behavior, little is known about how they interact with contextual factors. The third study of the current thesis aimed to examine how children during middle childhood modulate risky decision-making to changing incentive contexts, and how these processes are affected by temperament. The revised RST (r-RST; Gray & McNaughton, 2000) was used as a conceptual framework for generating hypotheses regarding the joint influence of temperament and situations factors. According to this theory, risky decision-making is determined by the relative activation of the Behavioral Activation System (BAS), the Fight-Flight-Freeze-system (FFFS), and the Behavioral Inhibition System (BIS), which are activated depending on their sensitivity and the strength of the relevant input. Since risk-taking in childhood has been related to maladaptive behavior later in development, it is relevant to find the factors behind it in order to be able to prevent it.

Background

The word temperament stems from the Latin word temperamentum (correct mixture), which in turn derives from temperare (to mix). Temperament and human personality have intrigued scientists since before the ancient world. The ancient medical concept of humorism, evolved by the Greek physician Hippocrates (460–370 B.C.), posits that the human body is filled with four distinct bodily fluids called humors, which are in balance when a person is healthy: phlegm, blood, black bile, and yellow bile (Haustgen, 2014; Hippocrates). An excess or shortage of one of the humors would result in an imbalance in the others. Individual behaviors hence could be understood as a blend of bodily fluids in balance or imbalance. Galen (A.D. 131–200) searched for physiological reasons for different behaviors in humans and in his dissertation *De Temperamentis* he developed the first typology of temperament (Galenos & Linacre, 1527; Stelmack & Stalikas, 1991). Galen mapped the four humors onto a matrix of hot/cold and dry/wet, after the four elements, and named the temperamental categories phlegmatic (calm and distant), sanguine (driven and untroubled), melancholic (gloomy and analytical), and choleric (rash and irritable) after the bodily humors, respectively (Stelmack & Stalikas, 1991). Although humorism is more than a thousand years old, personality type systems continue to use categories of a similar nature.

A recurring dilemma has been whether or not human personality is determined uniquely by an individual's innate qualities, or if it is our life experiences that form our behavior. The nature versus nurture conflict is discussed by Aristotle (384–322 B.C.) in the first known textbook of psychology *De Anima* (Aristotle & Hammond, 1902). The conflict concerns the relative importance of an individual's constitutional qualities (nature) versus his or her acquired experiences (nurture), when determining individual differences in behavioral traits. The actual term "nature vs. nurture" was coined 1875 by Sir Francis Galton, cousin of Charles Darwin, in a scientific article about the influence of genetic endowment and environment on development (Galton, 1907). Galton's own research on the matter led him to the conclusion that the evidence favored nature rather than nurture.

Collaterally, English philosopher John Locke formulated the concept tabula rasa (blank slate). He proposed that children are born completely without mental content, although with some natural inclinations such as personalities, likes and dislikes (Locke, 1844). According to Locke, all human knowledge comes from experience or perception. We develop from environmental influences and each individual is therefore free to define his or her character. Locke thus is a follower of the nurture dogma; we are born free and we have the possibility to choose what we become. Another famous "nurturist" is John B. Watson, who established the school of behaviorism. Watson believed that the environmental influence on behavior by far exceeds any inherited traits a person might possess. Watson is the source of the somewhat extreme behavioristic statement: "Give me a dozen healthy infants, well-formed, and my own specified world to bring them up in and I'll guarantee to take any one at random and train him to become any type of specialist I might select – doctor, lawyer, artist, merchant-chief and, yes, even beggar-man and thief, regardless of his talents, penchants, tendencies, abilities, vocations, and race of his ancestors" (Watson, 1930, p. 82). In modern psychology, hardly any scientist would accept either of the extreme positions in the nature vs. nurture debate as a unique contributor to human personality and behavior. Rather, in later years, research has focused on their relative importance, how much each factor contributes, making way for research fields such as behavioral genetics.

Hans Eysenck was one of the most influential personality scientists of the last century. He first described two personality dimensions, extraversion and neuroticism (E and N), that provided a two-dimensional space to describe individual differences in behavior (Eysenck & Himmelwith, 1947). Eysenck noted that individual combinations (high, low) of the two dimensions created four personality types similar to those proposed by Hippocrates (Eysenck & Eysenck, 1985; Eysenck & Himmelwith, 1947). Eysenck and Eysenck (1977) later added psychoticism as a third dimension to the model. E and N share many similarities with the two motivational

systems in focus of this thesis, the punishment sensitivity system (N) and the reward sensitivity system (E).

In the 1980s, the general theory on temperament was developed by C. Robert Cloninger, based on data from genetics, neurobiology, and neuropharmacology (Cloninger, 1986). Cloninger described four independently inherited dimensions of temperament: harm avoidance, novelty seeking, reward dependence, and persistence. However, Cloninger found that these dimensions of temperament were not able to capture the full range of personality. Hence, he identified a complimentary second domain of personality traits, or character dimensions, to measure an individual's humanistic and transpersonal style, and arranged them into three variables: cooperativeness, self-directedness, and self-transcendence (Cloninger, 1986; Cloninger, 1987). On the basis of his theories, Cloninger developed the now widely used questionnaire the Temperament and character inventory (TCI; Cloninger, 1987).

A final example of a modern personality theory stemming from the theories of Hippocrates/Galen is The Five-Factor Model (Costa & McCrae, 1992). According to this theory, there are five broad and universal factors of personality, universally known as The Big Five and usually described with either of the acronyms OCEAN or CANOE: Openness to Experience/Intellect, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. Beneath each of these proposed global factors, researchers have found two separate, but correlated aspects, reflecting a level of personality trait dimensions. The aspects have been labelled: intellect and openness for Openness to Experience/Intellect; industriousness and orderliness for Conscientiousness; enthusiasm and assertiveness for Extraversion; compassion and politeness for Agreeableness; and volatility and withdrawal for Neuroticism (DeYoung, Quilty, & Peterson, 2007). The five-factor model has been the focus of extensive research and debate over the last decades, and today this robust model is one of the most widely used theories of personality.

What is temperament?

Temperament is typically defined as constitutionally derived individual differences in emotional, motor, and attentional reactivity (measured by latency, intensity, and recovery of response), and self-regulating processes that modulate this reactivity (Rothbart, 1981). Personality is generally regarded to be founded in temperament, and is under constant revision as the child develops, for example as a result of the emergence of self-regulation which helps the child to gain control over thoughts and behavior (Rothbart, 2011). Temperament can thus be regarded as the "nature" part of

personality, while context (upbringing, life experiences, culture, environment, etc.) constitute the "nurture" part.

The conception that distinct motivational systems underlie dimensions of human affect and behavior rests on biologically derived research and has had crucial impact on theories on temperament and personality (e.g., Cloninger, 1987; Depue & Collins, 1999; Gray, 1982; Gray & McNaughton, 2000; Rothbart, Derryberry, & Posner, 1994; Thomas & Chess, 1977). According to the Reinforcement Sensitivity Theory (RST; Gray & McNaughton, 2000), one of the most influential theories that also constitute part of the theoretical framework for this thesis, temperament reflects neuronal reactions in three biological systems: the Behavioral Activation System (BAS), the Fight-Flight-Freeze-system (FFFS), and the Behavioral Inhibition System (BIS). The BAS is an approach system sensitive to reward. The FFFS regulates active avoidance and is sensitive to punishment. The BIS responds to cues of both punishment and reward, and operates to reduce goal conflict between them (Gray & McNaughton, 2000). Temperament is typically also proposed to contain a self-regulatory aspect, sometimes named EC (Eisenberg, Edwards et al., 2013; Rothbart, Ahadi, & Evans, 2000), or constraint (Carver, 2005). This function is believed to be superordinate to the other systems and enables people to voluntarily inhibit, activate or modulate attention and behavior. It guides thoughts and actions, flexibly adapting to changes in the environment, in order to meet external and internal goals (Carver, 2005; Rothbart et al., 2000; Rothbart, Posner, & Kieras, 2006).

The Reinforcement Sensitivity Theory of Personality

The Reinforcement Sensitivity Theory of Personality (RST) is one of the major neuropsychological models of temperament. The RST is the product of the lifelong work of Jeffery A. Gray, and later his colleague Neil McNaughton. It is largely based on data from experimental biological and neuropsychological research, initially performed exclusively on animals in search of the biological basis for personality. Gray aimed to identify the brain-behavioral systems involved in individual variations of behavior and to relate these variations to existing measures of personality (Corr & McNaughton, 2008). The first model of the RST was published in 1982 (henceforth referred to as the original Reinforcement Sensitivity Theory, o-RST). In part, Gray presented it as an alternative to Eysenck's personality theory of extraversion (E) and neuroticism (N). The o-RST proposed a 30° rotation of E and N in factor space and also proposed neuropsychological bases of E and N. The o-RST included three major systems of emotion: the Fight-Flight System (FFS), the Behavioral Activation System (BAS) and lastly the Behavioral Inhibition System (BIS). While FFS was hypothesized to be sensitive to unconditioned aversive stimuli and BIS to conditioned aversive stimuli, BAS was sensitive to all appetitive stimuli (Gray, 1982). For many years, a

great deal of empirical research was conducted examining different aspects of the o-RST, but some fundamental aspects of the theory remained unclear.

Revised RST

In 2000, together with McNaughton, Gray published a revised version of the RST: the revised Reinforcement Sensitivity Theory (r-RST; Gray & McNaughton, 2000). The revised version also postulates three systems although they are defined differently than in the o-RST. First, the fight-flight-freeze system (FFFS) is proposed to be responsible for mediating reactions to all aversive stimuli. FFFS mediates fear, not anxiety, and is a negative feedback system responsible for reducing the discrepancy between the immediate threat and the desired state (Corr, 2004). FFFS is unique to the r-RST as no other personality theory involves a specific dimension for this system. Instead, similar traits such as volatility or harm avoidance are accommodated into a punishment sensitive trait such as neuroticism or negative affectivity (Kennis, Rademaker, & Geuze, 2013).

Second, the BIS is responsible for inhibition of prepotent behavior and resolution of goal conflict in general (BAS/FFFS, BAS/BAS, and FFFS/FFFS). It is a negative feedback system with the goal of solving the conflict to be able to return to the state of no conflict (Corr, 2004; Gray & McNaughton, 2000). Activation of the BIS in conflict entails increased levels of arousal and also assessment of the amount of risk involved in the situation, that is, when the BIS is activated the individual needs to gather information about the dangers of approach (Corr & McNaughton, 2008; Gray & McNaughton, 2000; McNaughton & Corr, 2004). The result of goal conflict can be either pure behavioral inhibition or exploratory behavior such as defensive approach. This state is recognized as worry or rumination in the individual. An anxious individual will be prone to perceive a threat as being closer in distance, and thus more intense, than it actually is. As a result, the anxious individual will be more inclined to avoidance behavior than to approach behavior (Corr & McNaughton, 2008).

Lastly, the BAS mediates reactions to all appetitive reward stimuli. It is a positive feedback system that urges to reduce the distance to the final biological reinforcer (Corr, 2004). It is conceptually different from the BIS and the FFFS; while the BIS is associated with anxiety and the FFFS with fear, the BAS is multidimensional and involves aspects of drive, fun-seeking, and reward responsiveness (Corr, 2002). This dissertation thesis uses the r-RST as a conceptual framework for temperament, together with the model by Rothbart (see below).

Behavioral control

Constraint, according to r-RST, is either about impulsivity or behavioral inhibition (Gray & McNaughton, 2000). The r-RST considers aspects of self-control to be cognitive level functions in motivated behavior. However, during the last decade, the addition of a potential additional dimension, Constraint, has been suggested (Carver, 2005; Kennis et al., 2013). A large review article identified a distinct higher order trait of constraint that was separate from extraversion and neuroticism (Depue & Collins, 1999). Constraint has been described as the ability to suppress impulses, thoughts, and emotions, as well as to override the tendency not to act (Carver, 2005; Rothbart et al., 2000). The constraint system is proposed to be involved mainly in self-regulation. The system thus has the potential to inhibit impulses, or overcome tendencies not to act (Carver, 2005; Kennis et al., 2013), and also to respond to tasks requiring effortful attention, such as task switching (Hofmann, Schmeichel, & Baddeley, 2012). Constraint thus shares many similarities with EC, as described by Rothbart (Corr, 2001). Although the notion of constraint has found support in research, thus far it has not made its way to become a factor of temperament in the r-RST.

The Joint Subsystem Hypothesis

The r-RST claims that BIS activation is depending on the activation of BAS, as it is in the conflict between appetitive and aversive stimuli that BIS is activated. The revised theory still suggests that BIS and BAS are orthogonal to one another, meaning that responses to punishment are equally strong on all levels of impulsivity and responses to reward equally strong on all levels of anxiety, a phenomenon that has been referred to as The separable subsystem hypothesis, SSH (Corr, 2001). However, an increasing amount of research indicates that this part of the r-RST is in need of reformulation. Corr suggests that the SSH is applicable only under certain conditions: when stimuli are very strong, in extreme BIS/BAS personality groups, and in experimental situations where either only appetitive or only aversive stimuli is being used (2004). Consistent with Gray's theoretical model, it needs only be assumed that the output of the decision mechanism is the sum of inputs, the subjective amplification of punishment and reward values, from both the BIS and the BAS (Corr, 2002). In 2001, Corr presented The Joint Subsystem Hypothesis (JSH), to account for the manner in which behavior is determined by the interaction between temperamental brain systems. JSH is based on the three separate brain-behavior systems formulated in the r-RST, and should be seen as an addition to the theory. The JSH suggests that BIS, BAS and FFFS are interdependent systems that all have the potential to influence behavior to punishment and reward (Corr, 2002). Hence, decisions rely on simultaneous input from both the BIS and the BAS.

Corr (2001) argued that the effect of BIS and BAS on personality is decided by the strength of the aversive or appetitive stimuli and affects behavior in two separate ways: Facilitatory and Antagonistic. In this view, risk-taking can be regarded as the result of a weak BIS/FFFS as well as an overly active BAS (Gray & McNaughton, 2000; Vermeersch, T'Sjoen, Kaufman, & Van Houtte, 2013). Research has shown that patterns of inputs from the BAS and the BIS/FFFS generate a large range of outcomes that support the JSH. The JSH is an important theoretical background to studies 2 and 3, since they investigate the joint influence of temperamental traits from the different motivational systems on risk-taking.

The r-RST and psychopathology

The r-RST has provided a useful framework for understanding the relationship between personality and psychopathology in both children and adults. Dysfunctions in sensitivity to punishment and reward have been reported in several frequent disorders during childhood, such as autism spectrum disorders, conduct disorder, and anxiety disorders, with the children at the extreme ends of the BIS/BAS dimensions most at risk (Morgan, Bowen, Moore, & van Goozen, 2014). Generally, the BIS has been related to internalizing symptoms, such as anxiety disorders and depression (Balle, Tortella-Feliu, & Bornas, 2013; Morgan et al., 2009; Sportel, Nauta, de Hullu, & de Jong, 2013). An elevated BAS has, much due to the sensitivity to reward, been associated with increased risk for externalizing problems: antisocial behavior, criminality, substance use, gambling, and also personality disorders such as psychopathy (Bijttebier, Beck, Claes, & Vandereycken, 2009; Gaher, Hahn, Shishido, Simons, & Gaster, 2015; Hundt, Kimbrel, Mitchell, & Nelson-Gray, 2008). A large amount of research has been addressing the relationship between the r-RST and substance abuse. The use of alcohol and drugs has many short-term rewarding properties, and reward sensitive individuals with an elevated BAS are more prone to abuse alcohol and drugs (Franken & Muris, 2005; Willem, Bijttebier, Claes, & Uytterhaegen, 2012).

There have been different attempts to conceptualize the r-RST in a questionnaire. Among the most commonly used instruments are the BIS/BAS scales (Carver & White, 1994), and the Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ; Torrubia et al., 2001). The SPSRQ is the adult version of the later developed version for children, the SPSRQ-C (Colder et al., 2011), which is one of the questionnaires used in our studies.

Rothbart's Model of Temperament

Mary K. Rothbart is one of the most influential contemporary researchers in the field of temperament and personality, and together with the r-RST, the model of

temperament developed by Rothbart and her research associates constitutes the theoretical framework for this thesis. According to Rothbart (2011, p. 7), "temperament describes our early emotional, motor, and attentional equipment, along with the regulative capacities that allow us to control our reactions and put them to good use".

Among Rothbart's many contributions to research is the development of a number of well-validated parent- and self-report questionnaires for assessing children's temperament at different ages: The Infant Behavior Questionnaire, at 3–12 months of age (IBQ; Rothbart, 1981), the Children's Behavior Questionnaire, at 3–7 years of age (CBQ; Rothbart, Ahadi, Hershey, & Fisher, 2001), The Temperament in Middle Childhood Questionnaire, at 7–11 years of age (TMCQ; Simonds & Rothbart, 2004), and The Early Adolescent Temperament Questionnaire-Revised, at 9–15 years of age (EATQ-R; Capaldi & Rothbart, 1992). Through factor analysis, several temperamental subscales have been extracted and clustered into three temperamental factors (or systems): Negative Affectivity (NA), Surgency (SU), and Effortful Control (EC). The questionnaire used in this thesis is the Temperament in Middle Childhood Questionnaire (TMCQ; Simonds & Rothbart, 2004), which will be described in detail later in this thesis, under the headline "Temperament questionnaires".

Negative Affectivity (NA) is present at birth and even though a newborn infant displays rather undifferentiated distress, it is soon possible to see more distinct negative affects (Rothbart, 2011). The measurement of NA includes subscales Anger/Frustration, Discomfort, Fear, Soothability (negative loading), and Sadness (Rothbart et al., 2001). Fearful approach inhibition is thought to protect the individual from potentially harmful situations. Temperamental fearfulness is visible by the end of the child's first year and shows stability over time (Baker, Baibazarova, Ktistaki, Shelton, & Van Goozen, 2012; Caspi, Roberts, & Shiner, 2005). According to Rothbart, fear regulates approach and aggression, resulting in greater control of action. High levels of fear might lead to rigid patterns of behavior in over-controlled individuals (Rothbart, 2011, p. 55). Frustration in infancy has been related to both later negative emotionality and surgent approach behavior (Rothbart et al., 2000). The role of anger in NA has been questioned by some researchers, who suggest that anger is related to both temperamental approach and avoidance tendencies. This relationship has also been convincingly argued for by Carver (2004), and Watson (2009). In a large meta-analysis on gender differences in temperament, small but significant gender differences were found for the NA factor. The differences were found in the Fear subscale, where girls tended to be more fearful than boys (Else-Quest, Hyde, Goldsmith, & Van Hulle, 2006).

Surgency (SU) is described as approach tendencies, or an accelerator towards action. It combines positive emotionality and approach tendencies with a high activity level

(Evans & Rothbart, 2009). The SU factor is proposed to include subscales Activity Level, High Intensity Pleasure, Impulsivity, and Shyness (reversed). Individual differences in surgent approach tendencies can be measured in infancy and longitudinal stability has been reported from early in development (Rothbart & Bates, 2006). For example, high activity levels in infancy can predict high activity levels (Korner et al., 1985) and high impulsivity (Caspi & Silva, 1995) later during childhood. Children's tendency to express positive emotions appears to be independent of their expressions of negative emotions, indicating that positive and negative emotionality are separable and, in fact, orthogonal (Kochanska, Coy, Tjebkes, & Husarek, 1998; Tellegen, Watson, & Clark, 1999). Temperamental surgency predicts later externalizing problems (Hagekull, 1994; Rothbart et al., 2000), but appears to be unrelated to internalizing problems (Caspi & Silva, 1995). Rothbart (2011, p. 228), discusses the possibility that children high in positive emotionality are more likely to elicit positive emotions in adults, which protects them when they're growing up. However, other studies suggest that very strong surgent approach tendencies may constrain the development of self-regulation (Rothbart et al., 2000), and set the child at risk for developing externalizing problems (Rothbart & Bates, 2006). In the previously mentioned meta-analysis on gender differences in temperament, the SU factor showed very small gender differences, indicating that boys are slightly more active, less shy, and more prone to feel pleasure than girls in high-intensity situations (Else-Quest et al., 2006).

The third temperamental system, Effortful Control (EC), is superordinate to the approach and avoidance systems, and has been defined as "the ability to inhibit a dominant response in order to perform a subdominant response, to detect errors and to engage in planning" (Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005). It can also be seen as the ability to control actions, emotions, and attention (Rothbart, 2011). EC is involved in the voluntary control of thoughts and feelings, in resolving conflict in regard to discrepant information, correcting errors and planning new actions. In a sense, it brings a meta-perspective to temperamental affect; it provides us with the opportunity to observe our own actions, and to decide to choose a different action based on our goals and values (Rothbart, 2011). EC thus brings flexibility to our thoughts and actions. Even though not detected in early infancy, EC evolves rapidly in children between 2 and 7 years (Rothbart, Sheese, & Posner, 2007; Rothbart, Sheese, Rueda, & Posner, 2011), and continues to develop throughout childhood, adolescence and into early adulthood. Several studies on gender differences in EC have found that girls generally display greater ability to regulate attention and impulses (Else-Quest et al., 2006). Girls' higher levels of EC have also been suggested as the reason behind girls producing better results in school, than do boys (Carvalho, 2016).

The concept of EC has gradually evolved and today, it is generally regarded a heterogeneous construct, a configuration of inhibitory control, attention control/effortful attention, and activation control (Eisenberg & Sulik, 2012; Rothbart & Bates, 2006). Inhibitory control is defined as the individual's capacity to inhibit inappropriate behavior when needed, and when he or she doesn't want to do so (Eisenberg & Sulik, 2012; Evans & Rothbart, 2009). Attention control/effortful attention refer to the ability to focus attention on a task and to shift when desired, which requires conscious effort (Evans & Rothbart, 2009). Finally, activation control is defined as the capacity to perform an action when there is a strong tendency to avoid it and to persist at a difficult or unpleasant task (Eisenberg, Hofer, Sulik, & Spinrad, 2014; Simonds & Rothbart, 2004).

Eisenberg et al. (2004) proposed a distinction between regulative (effortful) control and reactive control over action. Reactive control is sub-cortical, immediate and unconscious and can be further divided into two separate aspects: reactive under-control and reactive over-control. Reactive under-control corresponds to impulsive approach behavior and over-control corresponds to rigid, highly constrained behavior in response to novelty or threat (Eisenberg et al., 2007). In terms of the r-RST, these two aspects of reactive control would conceptually correspond to a highly sensitive BAS and BIS, respectively.

The importance of Effortful Control across development

An increasing amount of research has proven EC to be intimately related to social, moral and cognitive development in childhood. EC has been associated with several important developmental outcomes; children high in EC have less behavioral problems, and are more successful in school (Eisenberg, Valiente, & Eggum, 2010); they are also more socially competent (Eisenberg et al., 2010), and emotionally stable (Gaertner, Spinrad, & Eisenberg, 2008). Inhibitory control, one aspect of EC, is suggested to be important to active inhibition of antisocial behaviors as well as acquisition of prosocial behavior (Kochanska, 2000; Kochanska et al., 1998; Rothbart et al., 2000). Indeed, it seems that low levels of EC can lead to maladaptive development, and also to externalizing and internalizing psychopathology (Eisenberg et al., 2009; Muris, 2006; Muris, Meesters, & Rompelberg, 2007; Muris & Ollendick, 2005).

It has been established that EC has the ability to moderate the relation between contextual risk and adjustment problems. Children low in EC experience more adverse effects of contextual risks (such as low socioeconomic status, high-risk neighborhoods and insufficient parenting), than peers with good EC abilities (Lengua, 2003; Lengua, Bush, Long, Kovacs, & Trancik, 2008). In one study, attention regulation and inhibitory control (both aspects of EC) moderated the association between cumulative risk and adjustment problems (Lengua, 2002).

Contextual risks were more strongly related to adjustment problems for children with low levels of EC capacities, compared to children with higher levels (Lengua, 2002). It thus seems that EC is one of the most important abilities to develop as it promotes a healthy and auspicious development in several of the most important areas during childhood.

Differences and similarities between the theories

While constraint is not a unique factor of temperament in the r-RST, the Rothbart model postulates that EC is superordinate to approach and avoidance temperament (Rothbart & Bates, 2006). In the current thesis, we use the r-RST and Rothbart's model of temperament as conceptual frameworks (see below). The two theories are interrelated and share many key features. To begin with, both theories rest on a great volume of solid neurobiological research. They also propose the existence of two motivational systems in temperament, a punishment sensitivity system that regulates avoidance tendencies, and a reward sensitivity system that regulates approach tendencies. However, there are also some fundamental differences. Both the o-RST and the r-RST are biologically derived with an emphasis on the function and organization of neurological reactions and processes. The Rothbart model on the other hand, is better described as a structural model and aims to organize behavioral traits into higher order factors of temperament. Furthermore, thus far, the r-RST does not include EC as a unique temperamental system, while Rothbart stresses the importance of EC in temperament. As previously described, recent research does indeed suggest aspects of EC to be part of constitutional temperament (Carver, 2004; Eisenberg, Edwards et al., 2013; Rothbart et al., 2000), and hence, in line with the Rothbart model, this thesis has conceptualized EC as a unique factor of temperament.

A key feature of the r-RST is that it distinguishes the systems that underlie fear and anxiety (FFFS and BIS, respectively). According to the r-RST, FFFS-fear and BIS-anxiety control the opposite motivational tendencies of withdrawal vs. caution approach (Corr & McNaughton, 2008). The Rothbart model, however, does not make such a distinction. In fact, anxiety is not a unique temperamental trait according to Rothbart, and the terms fear and anxiety are sometimes used together to describe fearfulness (e.g., Rothbart et al., 2000). Rothbart has also described anxiety as a behavioral adjustment to fear (Rothbart et al., 1994). Anxiety is neither included in the NA factor, nor is it assessed by the temperamental questionnaires from the Rothbart lab. Much research supports the r-RST in making this important distinction between fear and anxiety, thus potentially indicating a theoretical inadequacy in the Rothbart model. This thesis does not take theoretical standpoint for either theory, but rather uses them as complimentary of each other.

Developmental aspects of temperament

Developmental studies have been able to establish that executive functions appear to emerge in three stages of maturation: early childhood, middle childhood, and adolescence (Brocki & Bohlin, 2004). Middle childhood is a transition period between early childhood and adolescence. During this period, brain activity and behavioral responses advance, partly due to myelination within the corpus callosum and subcortical areas, enabling increased conduction speed and synaptic transmission between the right and left hemisphere (Mah & Ford-Jones, 2012). The children's thoughts become increasingly abstract, behaviors and emotions increasingly controlled and their decisions more independent (Toga, Thompson, & Sowell, 2006). In general, children during middle childhood have acquired the capacity to take the probability and magnitude of potential outcomes into consideration when evaluating choice options (Van Leijenhorst, Westenberg, & Crone, 2008; Levin, Weller, Pederson, & Harshman, 2007; Weller, Levin, & Denburg, 2011). Also, they have generally developed metacognitive capacities that allow them to deliberately engage in deliberate control over behavior and invest cognitive resources suitable for the demand characteristics of the task (Schneider, 2010). The development of self-regulation skills is hence characterizing of middle childhood.

Adolescence is characterized by hormonal, physiological, and physical changes, as well as changes in social roles and responsibilities. During puberty, the limbic structures of the adolescent brain are more mature than the prefrontal areas, which entails that rewards are perceived as much more alluring than during many other life periods (Crews, He, & Hodge, 2007; Davey, Yücel, & Allen, 2008). There is a steep increase in delinquency between ages 10 and 17, after which it decreases again at the same speed (Evans-Chase, Kim, & Zhou, 2013; Steinberg et al., 2008). Two predictable processes have been identified as possible explanations for this relationship. Firstly, there is a process in early adolescence (it peaks in middle adolescence and diminishes rapidly through late adolescence); described as a neurologically determined spike in reward-seeking behavior, that often expresses itself as an increase in sensation-seeking and risk-taking (Doremus-Fitzwater, Varlinskaya, & Spear, 2010). The second process is the slow neural development of self-regulation, a process that does not appear to be fully matured until the early 20s (Steinberg, 2008).

Research indicates that the presence of peers increases risk-taking among adolescents but not adults (Chein, Albert, O'Brien, Uckert, & Steinberg, 2011; Gardner & Steinberg, 2005), and that this is due to the heightened sensitivity to the reward value of risky decisions (Chein et al., 2011). Studies suggest that adolescents' risk-taking and susceptibility to peer influence may be due to the developmental succession in neural maturation of the inhibitory control system and the socioemotional reward system (Albert, Chein, & Steinberg, 2013). Inhibitory control skills hence increase

during adolescence, allowing focused attention and enabling the individual to regulate emotions and behavior (Crone & Dahl, 2012). However, as the brain regions associated with more affect-based motivational tendencies have a developmental head start, adolescence is characterized by suboptimal decisions and risk-taking behavior (Steinberg, 2008; Van Leijenhorst et al., 2010).

Given the advances in self-regulation and decision-making during middle childhood, it is likely that children during this period will handle risky decision-making in a more mature way than during early childhood. They are also still un-affected by the "out-of-sync" brain maturation of adolescence. Hence, middle childhood is an age span appropriate for such research interventions as we intended to perform, since children during middle childhood gradually gain inhibitory control skills with an increasing ability to respond selectively to stimuli (Mah & Ford-Jones, 2012).

Assessing temperament

Assessing temperament and personality is a fastidious task, as the immediate and innate reactions to threat that elicit temperamental motivational reactions, are not easily translated into human experimental studies. Furthermore, personality includes a much broader range of individual differences than temperament. A large proportion of contemporary research on temperament and personality is performed using questionnaires. When childhood temperament is to be assessed, the most common way to assess it is through parental, teacher, or self-reports of the child's behavior. Questionnaires are easy to administer and a practical assessment method, and research on children's temperament that does not use parental and/or teacher questionnaires is scarce. Other techniques such as behavioral observations and laboratory measures are more expensive and complex to administer, and fewer validated measures are available.

The use of parental questionnaires has often been challenged. It has been argued that parental bias in reporting on child temperament is systematic and comprehensive (Seifer, 2003), and that parents' perceptions of their children's behavior and temperament may be biased by their own cultural and gender stereotypes (Else-Quest et al., 2006). Furthermore, studies have revealed that parental reports of child behavior only correlate moderately with teacher reports (Achenbach, McConaughy, & Howell, 1987), which has been used as another argument against the use of parents as reports of their children's characteristics. However, parents have by far the most experience with their child and can therefore be considered to be the best provider of data on their child's characteristics. Moreover, studies show that the more you know someone, the less likely your judgement will be biased by stereotypes, such as gender (Else-Quest et al., 2006). Hence, teacher reports are more likely to be clouded by stereotyping, as teachers know the children less than their parents do, and meet the

children when they are interacting in peer-groups where gender differences are often magnified (Else-Quest et al., 2006). Although not completely satisfactory, parental reports hence can be seen as a good way of assessing temperament and personality in children.

Executive functioning

Executive functions refer to a broad set of higher level processes that control and modulate cognition that supports action control and allows for goal directed behavior. Executive functioning has been associated with several adaptive developmental outcomes, such as high school performance and social competence (Blair & Razza, 2007; Hughes & Ensor, 2007), and is also a predictor of life outcomes such as socioeconomic status (Karbach & Unger, 2014), job success (Bailey, 2007), marital harmony (Eakin et al., 2004), as well as psychological (Penadés et al., 2007) and physical health (Crescioni et al., 2011).

Contemporary developmental research suggests that executive functions exist as early as the first years of life (e.g., Bell & Cuevas, 2016; Diamond, Prevor, Callender, & Druin, 1997), and that the period between 4 and 7 years is of particular importance for developmental change (Carlson, 2005). Furthermore, several studies indicate that executive functions develop continuously during childhood (Carriedo, Corral, Montoro, Herrero, & Rucián, 2016), and keeps improving during adolescence and into early adulthood. This successive functional development is suggested to rely on the structural maturation of the frontal cortex, for example, the increasing density of dendrites and synapses, and the myelination of prefrontal cortex (Ullman, Almeida, & Klingberg, 2014). Research findings have also been able to provide longitudinal support for a progression with age towards more complex executive functioning (Garon, Bryson, & Smith, 2008).

There is some level of pandemonium regarding which terms to use when discussing the various executive functions. In large, the terms *Inhibitory control* and *Self-regulation* suggest the same type of functioning. Self-regulation includes response inhibition, attention inhibition, and the ability to maintain optimal levels of emotional, motivational, and cognitive arousal (Diamond, 2016). The biggest difference between the two is that self-regulation primarily refers to control and regulation of one's emotions (Eisenberg et al. 2010; Mischel & Ayduk, 2004), while inhibitory control focuses more on thoughts, attention, and actions (Diamond, 2016). Self-regulation, with its focus on emotion, is perceived as the most appropriate term to use when describing motivated behavior and subsequently most appropriate for the purpose of this thesis.

The temperamental aspect of EC, that constitutes a focus of interest in this thesis, is sometimes referred to as the "innate temperamental predisposition to exercise better or worse self-regulation" (Diamond, 2016). EC is a good example of the sometimes confusing taxonomy since, according to Rothbart, inhibitory control is one of several sub-dimensions of EC rather than being a collection of functions (self-control, cognitive inhibition and selective attention) as suggested by research (Diamond, 2016). In this thesis, when inhibitory control henceforth is discussed, we refer to the temperamental subscale of Inhibitory Control, rather than the executive function.

Generally, three basic components of executive functioning have been suggested (e.g., Diamond, 2016; Miyake et al., 2000): inhibitory control (including behavioral inhibition and selective attention), working memory (WM), and cognitive flexibility. The first core function is inhibitory control, which allows us to control our behavior, thoughts, emotions, and our attention. It also helps us to suppress impulses and choose other, more appropriate courses of action. Inhibitory control of attention provides us with the possibility of selectively attending a specific focus, staying focused and suppressing attention to other stimuli (Diamond, 2016). Self-control is an aspect of inhibitory control that involves control over behavior and emotions. Research has shown that inhibitory control tends to cohere more with WM than with other types of inhibition (Diamond, 2016). Some research suggests that a distinction needs to be made between inhibitory control that only requires inhibition of a motor response, *simple inhibition*, and inhibition that also requires WM processes, *complex inhibition* (Diamond et al., 2007). The distinction between the two types of inhibition has been validated through factor analyses, where data from simple and complex inhibitory tasks have clustered into separate factors (Brocki & Bohlin, 2004; Murray & Kochanska, 2002).

WM is another of the core executive functions, and is sometimes divided into verbal and visuo-spatial (nonverbal) WM. WM capacity develops during childhood and have been found to be a strong predictor of future academic performance, in particular achievements in mathematics and reading (Schwaighofer et al., 2014). To keep information in WM, your mind must be focused, and in order to focus, internal and external distractions must be inhibited. Inhibitory control is believed to support WM as it can keep irrelevant information out by suppressing irrelevant and/or redundant information (Diamond, 2016). Some researchers suggest that inhibition is a derivate of WM; it is the activation towards a goal that is relevant, not whether or not the goal is reached by inhibiting an impulse (Hanania & Smith, 2010; Nieuwenhuis & Yeung, 2005). According to yet another theory, the limited resource model, inhibitory control and WM depend on the same limited-capacity system so that increasing strain on either of them will affect the ability to activate the other (e.g., Baumeister et al., 1998; Engle & Kane, 2004; Wais & Gazzaley, 2011).

The third of core functions is cognitive flexibility, which develops later than inhibitory and WM and also builds upon these functions. Cognitive flexibility is about changing how we think about something, and also involves being able to adjust to changed demands, to admit you were wrong, and to take advantage of unexpected opportunities. Cognitive flexibility is thus the opposite of rigidity, and closely related to creativity (Diamond, 2016).

Executive functioning during childhood has been found to predict important developmental outcomes. In a follow-up study to the groundbreaking work on delay of gratification by Mischel and colleagues in 1970s, the adolescents who as children in the study had either succeeded or failed at refraining from eating a marshmallow in order to receive a larger reward, were examined. Adolescents that had been successful at delayed gratification as children had better concentration, self-control, and frustration tolerance; they were less likely to use drugs and were also judged by parents and peers to be more interpersonally competent, than the children that had been unsuccessful at delayed gratification (Mischel, Shoda, & Rodriguez, 1989; Shoda, Mischel, & Peake, 1990). Furthermore, a contemporary longitudinal study found that self-control, measured between ages 3 and 11 years, predicted physical health, substance abuse, socioeconomic status, and convicted criminal offences (Moffitt et al., 2011). Thus, research indicates long-term stability of early individual differences in executive functioning, and that such differences have significant long-term consequences for many different aspects of a person's life.

Hot and cold cognitive processes

Some contemporary research proposes that the executive functions can be divided into two systems, with pronounced (hot), and less pronounced (cold) emotional salience, respectively. The hot system is usually described as quick, implicit, and automatic in activation and processing, and to be involved in perception of affective material (Kahneman & Tversky, 2003). Decision-making has been considered a hot executive function that involves emotional processing (Bechara, Tranel, Damasio, & Damasio, 1996). The cold system refers to the volitional and controlled processing of declarative knowledge. It is associated with analytical, rational processing, and planning, and is involved in voluntary self-regulation of emotions (Schaefer et al., 2003). The hot system requires fewer processing resources than the resource demanding intentional reasoning processes of the cold system, which is an advantage in situations where split-second decisions are necessary. The reflexive responding of the hot system can be a nuisance to the cold system in risky decision-making, since the necessary determining of the probability of potential outcomes might be omitted. This also entails that the errors of the hot system can be overcome with the conscious deliberation of the cold system. Furthermore, perceived state of conflict, or any uncertainty experienced in a situation, is the result of activation of the cold system (Kahneman, 2003). Even though emotion regulation is gradually evolving during

adolescence it is not fully developed until early adulthood, and adolescents seem to be especially prone to engage in risk-taking behavior in the context of hot cognitive processes (Metcalfe & Mischel, 1999; Steinberg et al., 2006).

Training of executive functions

Since executive functioning is of central importance to many aspects of human behavior, interventions set out to improve this type of cognitive functioning are attractive and may serve an important purpose. In recent years, several types of training have been proposed. Such research is to a great extent performed on children, partially because childhood executive functioning is a strong predictor of various life outcomes, but also because neural plasticity is high during childhood and the brain sensitive to environmental influences (Bull et al., 2011). However, despite the increasing amount of research on training, results have been somewhat inconsistent across studies and have shown limited transfer effects to activities of everyday life. Hence, questions about the clinical relevance of cognitive training have been raised (Melby-Lervåg & Hulme, 2013; Melby-Lervåg, Redick, & Hulme, 2016).

As previously described, executive functioning is generally regarded to comprise three core abilities: inhibitory control, selective attention, and working memory. Usually, when studying the effects of cognitive training on behavior, focus is on one of these core abilities at a time, but thus far none of the core functions has been found to be consistently susceptible to training. When training WM abilities in children, frequently used assessments are working memory span tasks, such as counting span or reading span (Barrouillet et al., 2009; Conway et al., 2005), and the *n*-back task (Owen et al., 2005; Verhaeghen & Basak, 2005). Recent research findings show that WM training has the potential to produce both immediate and long-term improvement on similar memory tasks (Jenni et al., 2015). Results regarding transfer effects of training and at what age the training provides the best effects, are inconclusive. WM training, however, has been able to produce transfer effects in several studies. For example, one study including pre-school children, was able to show significant improvement on a verbal WM task after performed WM training exclusively with visuospatial WM tasks (Thorell, Lindqvist, Nutley, Bohlin, & Klingberg, 2009). In a clinical sample of children diagnosed with ADHD, transfer effects of WM training were found, reducing symptoms of inattention, hyperactivity, and impulsivity (Klingberg et al., 2005). Studies that have established lasting transfer effects are scarce, and results from training seem to depend on the nature of the training, the transfer task and the participant's motivation (Karbach & Unger, 2014).

To train cognitive flexibility abilities, the exercise of task-switching has often been used. In such assignments, participants perform two or more simple decision tasks and switch between them upon a specific cue. Cognitive flexibility training has been

able to produce transfer effects, improving performance on similar but untrained tasks (near transfer) as well as on reasoning and WM tasks (far transfer) (Karbach & Kray, 2009).

Several studies have reported that aspects of EC, such as attention focusing, can be improved through training. In a study on attention control training on pre-school children, involving EEG recordings and DNA testing, training enhanced all of the measured components: inhibition, WM and cognitive flexibility (Rueda et al., 2005). The named study also found that training significantly improved both attention and intelligence in 4–6-year-old children. The conclusions drawn by Rueda et al., were that although the executive attention network develops under strong genetic control, it is possible to significantly improve attentional skills through educational interventions during development (Rueda, et al., 2005). Significant training effects on self-regulative capacities (sustained attention and behavioral inhibition) were also found in another study on attentional training in school-aged children with ADHD (Kerns, Eso, & Thomson, 1999). This study used a training program that included a variety of attentional processes such as selective attention, and attention shifting. Meditation has also been reported to discipline the mind in staying focused (Hölzel et al., 2011).

Resent research has shown that that individual traits of the child are important for the outcome of the training (Nemmi et al., 2016). A study on temperamental influences on cognitive training (Studer-Luethi, Bauer, & Perrig, 2015) found that short but intensive WM training can enhance cognitive abilities in children, with both near and far transfer effects. They found that children's EC abilities were essential to perform well in WM training and to improve significantly on the training task. The authors attributed this to these children's greater ability to focus attention on the task and to inhibit impulsive responses. Furthermore, results from this study show that good EC combined with low neuroticism was necessary for the benefits of the training to extend to non-trained abilities (Studer-Luethi et al., 2015). This leaves us with a potential dilemma: the better the EC abilities in a child, the more successful the training, however, the children most in need of cognitive training (e.g., the children with low EC abilities), are less likely to benefit from it.

Risk-taking

Risk-taking has been summarized as choosing the option with the higher outcome variability (Figner & Weber, 2011). Affective processes are highly influential on risk-taking behavior, and can influence decisions in several ways, such as by directing attention to certain features of choice options and ascribing subjective values to them (Weber et al., 2002), and when resisting or giving-in to temptation (Figner, Mackinlay, Wilkening, & Weber, 2009).A review study by Figner and Weber (2011)

points out five distinguishing features of risk-taking: It occurs in different domains; it involves hot and cool psychological processes; options that carry higher risk typically come with greater returns; the least attractive outcome in riskier options is typically worse than the safer option; and finally, risk-taking is not a single personality trait or a mere question of attitude, it is a highly complex process. Risk-taking behavior as such is thus generally influenced by the characteristics of the situation and the decision maker, and furthermore, by the interactions between situation and decision maker (Figner & Weber, 2011).

It has been suggested that it is necessary to decompose risk into sub-components, such as risk-perception and an evaluation of risk benefits, in order to provide a stable estimate of an individual's risk attitude (e.g., Weber et al., 2002). Risk attitude has been suggested to reflect the relative weight a person gives to risk and return in a decision-making situation. Selecting a riskier option because it promises higher returns has been described as a tradeoff between the two motivators (Figner & Weber, 2011). Weber (2001) found that while the degree of risk perceived in a situation varies depending on the characteristics of the situation, attitude to perceived risk shows consistency across situations.

Previous studies have concluded that risk-taking propensity is domain specific (Blais & Weber, 2001), and that this is true in multiple countries (Blais & Weber, 2006). Hence, risk-taking is not a behavioral trait that distinguishes an individual in every situation and context. Results from a meta-analysis on risk-taking across domains performed by Wang, Zheng, Xuan, Chen, and Li (2016), showed that individual differences in risk-taking propensity, and its consistency across domains, were regulated by both genetic factors and individually unique environmental experiences. The heritability ranged from 29% in financial risk-taking to 55% in safety, thus supporting the notion of risk-domain specificity. In the Wang study, correlations across the seven domains included in the study, were generally low. However, a common genetic factor that regulated moral, financial, and natural/physical risk-taking was discovered. A study by Johnson, McCaul, and Klein (2002), indicated that domain-specific differences in risk-taking could be understood as differences in the perceived level of risk and benefit associated with different situations and activities. Risk perception can hence be viewed as a variable that differs among individuals and as a function of content and context (Weber, 1999). This thesis focuses primarily on risk-taking in the gambling domain, as measured by the BART-Y (Lejuez et al., 2007), and the newly developed test RDMT (Bengtsson, Nyström, & Van De Weijer, 2016).

Developmental aspects of risk-taking

Neuroscientific research has been able to isolate structures in the adult brain that are important to processing risks. Brain regions believed to be important in risk-taking

include the sensory cortices, amygdala, hippocampus, ventral striatum, and various cortical regions (i.e., the orbital-frontal, prefrontal, dorsomedial, and ventromedial cortices; Boyer & Byrnes, 2009). Regarding adolescent risk-taking, dual-system models posit that heightened risk-taking during this period is the result of a maturational imbalance between brain systems. The system responsible for reward processing matures early in adolescence, and systems responsible for inhibitory control that do not mature until early adulthood (see Duell et al., 2016; Steinberg, 2008). Research on risk-taking during adolescence suggests that the emergence, increase, and peak of risk-taking behaviors are associated with psychobiological development, including synaptic pruning, a shift from greater relative posterior to frontal activation, a decrease in inhibitory MAO and GABA, an increase in excitatory dopamine and androgenic hormone levels, and a general physical maturation (Boyer & Byrnes, 2009). For example, an increase in the density of a dopamine transporter, DAT, has been suggested to lead to limitations in the adolescent's ability to maintain reward-related motivation, hence resulting in a greater influence of immediate, short-term rewards, potentially contributing to impulsive-like behavior (Geier & Luna, 2009). Cross-sectional studies have concluded that the nucleus accumbens, an important region in the brain's reward circuitry (peaks in activity during adolescence relative to childhood when receiving rewards; Braams et al., 2014), and that this neural response correlates with self-report real-life risk-taking behavior (Galvan et al., 2007). Another study found risky behavior during adolescence to be associated with an imbalance caused by different developmental trajectories of reward and regulatory brain circuitry (Van Leijenhorst et al., 2010).

Research has found risk-taking during early childhood to be associated with risk-taking during adolescence. Henry, Caspi, Moffitt, and Silva (1996) found that a temperamental lack of control at age 3 (akin to low levels of EC) predicted conviction of violent offenses at age 18. In a large study of temperament and risk-taking, EC was acknowledged as the most consistent correlate of adolescent problem behaviors (Honomichl & Donnellan, 2012). Risk-taking in younger children is associated with poor school performance and adjustment problems (Lengua, 2003; Lengua et al., 2008), and during later childhood and adolescence it is associated with more maladaptive high-risk behaviors such as drug abuse, violence, unsafe sexual behavior, excessive gambling, and delinquency (Lejuez, Simmons, Aklin, Daughters, & Dvir, 2004; MacPherson, Magidson, Reynolds, Kahler, & Lejuez, 2010).

Research has demonstrated that adolescents rate risks quite accurately compared to objective criteria, suggesting that adolescents give more weight to expected benefits than to other potentially negative effects of risk-taking (Johnson, et al., 2002). Zhang, Zhang and Shang (2016) found that adolescents' social risk-taking was the most pronounced of all of their risky behaviors, followed by recreational, ethical and health/safety risk-taking behaviors. Zhang et al. found that the highly sensation-

seeking individuals engaged in more thrill-seeking health/safety and recreational risky behaviors (such as gambling, fighting, drinking, and bungee jumping), but also were more prone to ethical risk-taking (such as lying to get benefits). The authors hypothesize that this is a result from the notion that such behaviors do not qualify as risky. They conclude that "risk perception and expected benefit have different functions on the multi-domain of risk-taking, and if risk-taking behavior differs across domains, then the mechanism behind it is also domain-specific" (Zhang et al., 2016).

Risk preference can be decomposed into a trade-off between perceived benefits and perceived risks in a situation (Weber & Hsee, 1998; Weber & Milliman, 1997). Adolescents' tend to have lower risk perception and higher expected benefit compared with adults, which can explain their higher risk-taking tendencies compared to adults (Horvath & Zuckerman, 1993). Adolescents seem to be especially prone to engage in risky behavior in the context of hot cognitive processes (i.e., under conditions of high arousal; Metcalfe & Mischel, 1999; Steinberg et al., 2006). In a study by Figner et al., (2009), adolescents were equally likely to children and adults to take risks in cold tasks, but in hot tasks they were more likely to take risks than the other two groups.

Risky decision-making

Decision-making has been defined as the mental process of choosing from a set of alternatives, that depends on three temporally and functionally distinct processes: (1) the assessment and formation of preferences among possible options, (2) the selection and execution of an action, and (3) the experience or evaluation of an outcome (Ernst & Paulus, 2005). The process of decision-making also involves analyzing alternatives against selection criteria such as costs and benefits, advantages and disadvantages, and with preferences. Much of the research on the influence of situational factors upon decision-making has been based upon the prospect theory (Kahneman & Tversky, 1988), according to which the decision-making process is influenced by relative apprehension of the proportion of losses and gains: People become risk-averse when they think they are a head, and risk-seeking when they think they are behind. Thus, individual risk-taking behavior is likely influenced by a combination of appraisal processes and situational variables.

Decision-making is often accompanied by conflict, and a conflict is resolved by making a choice between alternatives (Diederich, 2003). Some early studies suggested that children below 12 years of age are incapable of making informed decisions because they do not understand probability, and typically cannot make predictions based upon probabilistic information (Piaget & Inhelder, 1951/1975). However, more recent studies suggest that already 4- to 7-year-old children can differentiate random from certain outcomes, and make predictions based on odds ratios (see Boyer, 2006).

Generally, children during middle childhood have developed an ability to take the probability and magnitude of potential outcomes into consideration when evaluating choice options (e.g., Weller, Levin, & Denburg, 2011). They also possess central meta-cognitive abilities that allow them to deliberately engage cognitive control over behavior and apply the appropriate cognitive resources suitable for a certain task (Schneider, 2010). Risk-related decision-making has been proposed to entail perceived risk, framing, emotions, and cost–benefit analysis (Soane & Chmiel, 2005). Judgement in risk-taking situations is particularly important during adolescence, as teens are confronted with numerous opportunities to engage in various risky behaviors (Boyer & Byrnes, 2009). Studies have shown that adolescents generally are more sensitive to rewards than children and adults and, relatedly, that rewards might heavily bias decision-making during this period of development (Geier & Luna, 2009). It has been suggested that one's level of deliberation influences the likelihood of one engaging in maladaptive risk-taking activities (Fischer & Smith, 2004). In child development, the ability to take some time to think before making a decision has been linked to several important developmental outcomes (Fischer & Smith, 2004; Takano, Takahashi, Tanaka, & Hironaka, 2010). Deliberation before making a decision thus may be a protective factor against engaging in risk-taking behavior.

Emotions in decision-making

Emotions have been reported to play a crucial role in decision-making, and to be of central importance to decision-making under risk (Damasio, 1994; Shiv, Loewenstein, Bechara, Damasio, & Damasio, 2005). According to the somatic marker hypothesis (Damasio, 1994; Damasio & Damasio, 1994), a defect in human emotional functioning is a vital factor in impaired decision-making. The somatic marker hypothesis rests on the assumption that reasoning and decision-making depend on conscious and unconscious cognitive operations that in turn depend on: (1) activity in sensory cortices; and (2) on support processes such as attention, working memory, and emotion. Emotional reactivity (i.e., somatic marker) allows the individual to avoid disadvantageous options and to develop a preference for advantageous ones. The somatic marker hypothesis has been extensively empirically investigated, usually using the Iowa Gambling Task (IGT; Bechara, Damasio, Tranel, & Andersson, 2005), which is one of the more popular and well-tested behavioral measures of risk-taking in adults.

Research using the IGT has focused on differentiating adults that engage in various forms of substance abuse, and results indicate that adult drug abusers are more prone to risk-taking on the IGT, than the non-drug-abusing adults (Bechara et al., 2001). The IGT is a card game in which participants are instructed to win as much money as possible by drawing cards from four decks of cards: A, B, C, and D. Feedback on gains and/or losses is given after each selection. The four decks differ in the magnitude of wins and losses and to succeed at the IGT, players must opt for the less

attractive but advantageous decks (C, D), and hence withdraw from the attractive but disadvantageous decks (A, B). Empirical support for the somatic marker hypothesis has been found by measuring anticipatory heart rate responses and skin conductance responses in participating players. Such somatic markers have been established as critical to distinguish good and bad performers in the IGT, thus suggesting a key role of anticipated emotional reactivity in advantageous decision-making (see Cassotti, Aite, Osmont, Houde, & Borst, 2014). Other studies have found evidence for a lack of emotional reactions leading to more advantageous decisions in certain situations (Shiv et al., 2005). Hence, emotions are of great importance to individual decision-making, but can be either useful or destructive depending on the circumstances. Using the IGT in adolescent research has shown that adolescents, compared to adults, are more oriented towards approach in response to positive feedback and less avoidant in response to negative feedback (Cauffman et al., 2010). Furthermore, results from one study indicated that approach behaviors display an inverted U-shape relation to age, peaking in mid- to late adolescence, while avoidance behaviors increase linearly with age, with adults avoiding disadvantageous decks at higher rates than both preadolescents and adolescents (Cauffman et al., 2010).

There is also a children's version of the IGT, named the Columbia Card Task (CCT). The CCT is a newer measure of risky decision-making, designed to measure both hot and cold decision-making and assessed using a computer (Figner, Mackinlay, Wilkening, & Weber, 2009). At the start of each trial, participants are informed about the number of potential loss cards, the amount to be won per win card, and the amount to be lost with a loss card. In the hot condition, participants are told to turn over as many cards as they want to, by clicking on them on the computer screen. They can stop the trial at any time by pressing a stop button. If a loss card is selected by the participant, the trial is over and the loss amount is deducted from the total score. The participants are given feedback about the number of points won or lost after each selection and at the end of each trial. In the cold condition participants are presented to a series of numbered buttons (0 to 32) on the computer screen. Instead of clicking on cards to turn them over, participants click the button indicating the total number of cards to select on the trial. This action ends the trial, and no feedback is given to the participant regarding the amount of points gained or lost.

Temperamental influences on risk-taking

The three temperamental factors proposed by Rothbart, NA, SU and EC, can be observed already during infancy (Casalin, Luyten, Vliegen, & Meurs, 2012). During the course of childhood, the temperamental traits evolve and, across time, external factors contribute to the shaping of temperamental characteristics. A lot of effort has been put into trying to identify what temperament and personality traits lie behind risk-taking behavior. Research has to a large extent focused on aspects of self-regulation and impulsivity, both of which are multifactorial concepts with several

subtypes of behavior reflecting distinctive neurological and cognitive processes (Eisenberg et al., 2013; Winstanley, Eagle, & Robbins, 2006). For example, EC has been found to play an important role in the regulation of reactive approach/avoidance tendencies in risk and/or reward situations (Blair & Diamond, 2008).

The exuberant temperament in particular, has been successfully linked to risk-taking (Lahat et al., 2012; Polak-Toste & Gunnar, 2006; Stifter, Putnam, & Jahromi, 2008). Exuberant temperament has been posited as a combination of easily provoked positive affect and a fearless approach to novelty and social interaction, making it quite similar to SU or the BAS (Polak-Toste & Gunnar, 2006; Rothbart et al., 2001). Sensation-seeking is a personality trait often linked to reward sensitive temperament. Research has found that individuals with a sensation-seeking personality profile are more likely to be exposed to, or create, opportunities to take risks than individuals low on sensation-seeking (Steinberg, 2008; Rothbart et al., 2000). Figner and Weber (2011) have argued that risk-taking varies as a function of the characteristics of the decision maker, the decision domain, and the context. Such line of reasoning taps onto the central theme of this thesis.

Temperament and risk-taking in a context

While temperament can be said to constitute an individual and biological vulnerability factor during development, the child's environment can be regarded as a contextual risk factor during childhood. Socioeconomic context, psychosocial factors, culture, zeitgeist, and life-experiences, are believed to have crucial influence on personality as they influence the child's development and how the child interacts with and interprets the environment (e.g., Kohnstamm, 1989; Lengua et al., 2008; Rothbart & Bates, 2006; Tackett et al., 2012).

It is important to note that all child development occurs within a social and cultural context, which itself develops and unceasingly interacts with the developing child (Bronfenbrenner, 1978). According to *The vulnerability model* (Shiner & Caspi, 2003) temperament plays a causal role in the development of psychopathology, as temperament can affect the way children interpret their own experiences, the way adults and peers respond to the child, the choices the child makes in day-to-day environments and the ways that the child manipulates or modifies his or her environment. Another model, *the mediational model*, suggests that children's temperament influences their environment, which in turn influences whether psychopathology develops or not (Fairchild & MacKinnon, 2009).

Contextual factors contribute to child development in general, but also shape the development of adjustment problems. Factors such as low income or poverty, exposure to high-risk neighborhoods, and household density are all associated with greater adjustment problems in children (Lengua et al., 2008). Each of these risk

factors can contribute to a negative and stressful context for children, and alas, risk factors tend to co-occur. One way for research to address the issue of co-occurrence of risk factors, is through a cumulative risk model (Lengua et al., 2008). Cumulative risk is a count of the presence of stable demographic, psychosocial, and environmental risk factors. Research focusing on counting cumulative risk has consistently found a relation between the number of risk factors present and children's cognitive, social, and psychological adjustment (e.g., Lengua et al., 2008; Liaw & Brooks-Gunn, 1994). One conclusion drawn from such studies is that developmental outcomes are better predicted by combinations of risk factors than by individual factors alone.

Parenting practice is an important environmental factor for the development of EC abilities. Studies reveal that consistent limit setting and non-punitive discipline are associated with high levels of EC (Karreman et al. 2008; Lengua 2006), whereas coercion, and punitive discipline have been related to lower levels of EC (Karreman et al. 2008; Kochanska & Knaack, 2003). Studies on parenting and risk-taking suggest that authoritative and authoritarian parenting styles, both high in disciplinary methods, generate adolescents who engage in fewer self-reported risk-taking behaviors than indulgent or neglectful (low discipline) parented adolescents (Goldstein & Heaven, 2000; Steinberg et al., 1994). It has been proposed that this effect is due to authoritative parents use of monitoring strategies that give them important information regarding where their child is, what their child is doing, and with whom (Laird, Pettit, Dodge, & Bates, 2003). It is generally acknowledged that peers facilitate risk-taking behaviors, both in a direct way, instigating risk-taking behaviors, but also indirectly contributing to the development of cognitive, affective, and psychobiological factors (Boyer & Byrnes, 2009). Indeed, self-report studies have repeatedly shown that children and adolescents who associate with peers that engage in risky behaviors are more likely to engage in risky behaviors (Gardner & Steinberg, 2005; Prinstein et al., 2001).

Culture is generally thought to have an all-important influence on personality development (LeCuyer & Zhang, 2015; Rothbart & Bates, 2006; Tackett et al., 2012). An increasing amount of studies focuses on personality in children, and cultural differences have been found as early as during infancy (Gartstein, Peleg, Young, & Slobodskaya, 2009). Several cross-cultural studies of childhood personality have revealed robust differences between individualistic cultures (such as the United States, Australia, and Sweden) and collectivistic cultures (such as Thailand, Japan, and China; Knyazev, Zupancic, & Slobodskaya, 2008; Rubin et al., 2006). In these studies, children in collectivistic cultures have been rated by their caregivers as much more behaviorally inhibited than those in individualistic cultures. In a study by Feldman et al. (2006) children's self-regulatory skills in individualistic and collective cultures were observed. Children in both groups achieved comparable levels of self-regulation in toddlerhood. However, in the individualistic culture, children were

better at persisting in activities and helping others, and in the collectivistic culture, children displayed more self-regulation in terms of rule compliance and emotion regulation (Feldman, Masalha, & Alony, 2006). Another study examined maternal-reported temperament including EC in US and Chinese children aged 6–7 years and found that EC was achieved about the same time in development in both countries (Ahadi, Rothbart, & Ye, 1993).

As for Swedish children, a longitudinal study has shown stability in individual differences in children's levels of different aspects of self-regulation (Chuang, Lamb, & Hwang, 2006). In a comparative personality study of adults in Sweden, Germany and the United States, significant differences were found on nearly all of the measured personality dimensions, although the Swedish sample and the German sample appeared highly comparable in score distributions for all dimensions, compared to the US sample (Brändström, Richter, & Przybeck, 2001). However, these results were based on an adult population, where the subjects have been "under the influence" of their own culture for quite some time. Hence, a larger difference is to be expected in an adult sample.

A study by Boyer and Byrnes (2009) suggests that gender- and age-related differences in risk-taking may be due to the fact that males and older adolescents are more often confronted with, or seek out, risky situations than females or younger adolescents. The authors conclude that, once in a risky situation, neither gender nor age can predict who will take a risk. In a large meta-analysis on gender differences in temperament (Else-Quest, Hyde, Goldsmith, & Van Hulle, 2006), significant differences were reported. Regarding the EC and the NA factors, significant gender differences were found, favoring girls. Girls were scored higher on subscales Inhibitory Control and Perceptual Sensitivity (EC), and Fear (NA). As for the SU factor, no gender differences were found in the meta-analysis. However, on a subscale level, significant gender differences were reported for High Intensity Pleasure and Activity Level, favoring boys. A large amount of studies thus reported gender differences in temperament where girls tend to be described as more fearful and self-controlled, and boys as more active and adventurous.

Although research has been able to establish that cumulative contextual risk is critical for maladaptive development in children, this is not necessarily true for all children. It appears that some children are resilient to cumulative contextual risk, demonstrating either few symptoms of maladjustment, or an overall positive adjustment (e.g., Cowen et al., 1992; Masten, 2001). Child characteristics have been associated with such resilience in children, and research suggests that children's EC may be an important child characteristic in determining how children respond to heightened contextual risk (e.g., Kim-Cohen, Moffitt, Caspi, & Taylor, 2004; Wyman, Cowen, Work, & Parker, 1991).

Summary of the Studies

Procedure

The three studies are overlapping as they are based on the same sample and the same questionnaires. The questionnaires will be described in detail below together with the computerized tasks that were used to study children's risk-taking behavior. The sample consisted of 157 middle-schoolers (N = 157; M = 9.87 years of age, SD = 0.67; 47% girls). The participating schools were situated in the southwest of Sweden. A closer inspection of the schools revealed that they were situated in either high or middle socioeconomic status areas, predominately inhabited by families with Swedish as their first language. Having this said, we have no information about the socioeconomic status, educational level, or first language of the individual participating families.

The rate of participation varied greatly between schools (between >80% and <20%). Highest participation rates were attained in schools where the teachers were highly committed to take part in the studies. Also, the level of participating families increased when the researcher visited the schools for testing on many occasions, increasing by repute the children's desire to take part in the study in quest for the rewards. All children that wanted to participate, and whose care-givers gave consent for them to do so, were included in the study, and hence no inclusion or exclusion criteria were used.

The questionnaires were filled in at home by the caregivers. The specific relation between the caregiver and the child (i.e., parent, foster parent, grand parent, et. c.) was not specified, nor if the questionnaire was filled in by one or two caregivers. The questionnaires were then sent back to the schools together with consent forms. The children were then tested individually in one single session at their own schools, each session lasting typically between 20 and 40 minutes. Formalized instructions were given in the beginning of the session and a practice round was offered before each test. All children played the RDMT and approximately one third of the children also played the BART-Y, hence the smaller sample size in study 2. In general, the children were very positive and enjoyed participation. Cinema vouchers and a diploma were offered to the children by the end of the session.

Questionnaires

Two temperament questionnaires were used, one from the Mary Rothbart lab and the other developed to assess important constructs within the r-RST. Both questionnaires were translated from English to Swedish using back-translation. Back-translation is a procedure that is performed in several steps. Initially, two Swedish researchers independently translated the questionnaires into Swedish and merged into one new version of each questionnaire. These were now sent to a language editor in Great Britain to be translated back into English. The new English versions were compared to the original by the researchers, and discrepancies between the different versions resulted in minor revisions of the translated material.

For solid cross-cultural research, translating questionnaires may entail more than just translating the words, and a systematic and thorough approach in several steps has been suggested (Abubakar, Dimitrova, Adams, Jordanov, & Stefenel, 2013). Since Swedish and English both belong to the family of Indo-European languages, and English is a highly familiar language to most Swedish people, we didn't believe it necessary with a translation as thorough as suggested by Abubakar et al. Both countries are also considered individualistic cultures and even if there are a great number of cultural differences, they also share many cultural traits. Even though our translations have not been thoroughly validated and adapted, we did not get any reactions from our participants that implied a difficulty understanding or relating to the items.

The Temperament in Middle Childhood Questionnaire (TMCQ)

The TMCQ (Simonds & Rothbart, 2004) is a caregiver questionnaire adapted for children between 7 and 11 years of age, where caregivers report on their children's temperamental traits. The TMCQ consists of 157 items describing the child, for example "Is always on the move" (15), "Tends to say the first thing that comes to mind, without stopping to think about it" (16), "Cheers up quickly" (26), and "Likes to play quiet games" (32). Items are divided into 17 temperamental subscales (dimensions), 14 of which are assigned to three factors, NA, SU, and EC (see Table 1). Out of the 17 subscales, 13 were developed and adapted via the Children's Behavior Questionnaire (Rothbart et al., 2001; Rothbart et al., 2007) and the rest elaborated uniquely for the TMCQ.

Table 1.
Temperamental factors and subscales of the TMCQ.

Factor	Subscale	Definition	Items (N)	Cronbach's alpha
Surgency	Activity Level	Level of gross motor activity including rate and extent of locomotion.	9	.63
	High Intensity Pleasure	Amount of pleasure or enjoyment related to situations involving high stimulus intensity, rate, complexity, novelty, and incongruity.	11	.79
	Impulsivity	Speed of response initiation.	13	.71
	Shyness (reversed)	Slow or inhibited approach in situations involving novelty or uncertainty.	5	.70
Negative Affectivity	Anger/ Frustration	Amount of negative affect related to interruption of ongoing tasks.	7	.83
	Discomfort	Amount of negative affect related to sensory qualities of stimulation, including intensity, rate or complexity of light, movement, sound, and texture.	10	.76
	Fear	Amount of negative affect, including unease, worry, or nervousness related to anticipated pain or distress and/or potentially threatening situations.	9	.78
	Sadness	Amount of negative affect, lowered mood and energy related to exposure to suffering, disappointment, and loss.	10	.74
	Soothability (reversed)	Rate of recovery from peak distress, excitement, or general arousal.	8	.69
Effortful Control	Attention Focusing	Tendency to maintain attentional focus upon task-related channels.	7	.90
	Inhibitory Control	The capacity to perform an action when there is a strong tendency to avoid it.	8	.75
	Low Intensity Pleasure	The capacity to plan and to suppress inappropriate approach responses in novel or uncertain situations.	8	.83
	Perceptual Sensitivity	Amount of pleasure or enjoyment related to situations involving low stimulus intensity, rate, complexity, novelty, and incongruity.	10	.85
	Activation Control*	Amount of detection of slight, low intensity stimuli from the external environment.	15	.81
[a]	*Affiliation*	Level of gross motor activity including rate and extent of locomotion.	10	.83
	Assertiveness/ Dominance	Tendency to speak without hesitation and to gain and maintain control of social situations.	8	.83
	Fantasy/ Openness	Speed of response initiation.	9	.86

[a] Note that three sub-dimensions of the TMCQ have not been included in the three temperamental factors. They constitute a hypothetical fourth factor "Sociability", which has later been rejected. * Experimental scale

Three subscales, Affiliation, Assertiveness, and Fantasy/Openness, have been suggested to form a potential fourth factor, Sociability (Simonds, 2006). However, to form such a factor, the developers of the test used additional data from other measures, making a unique Sociability factor for the TMCQ incomplete. As this factor still is experimental, the three proposed subscales were excluded from our data set. This is also the recommended method according to Simonds and Rothbart in the latest test-manual (Simonds & Rothbart, 2009). The same test-manual reports Cronbach's alpha values between .63 and .90 for all subscales, indicating generally good reliability. The subscale Activation Control has been tentatively appointed to the EC factor. This subscale has, according to the developers, experimental status and has not been consequently included in analyses when developing the questionnaire.

The items are rated on a 5-point scale, from "Almost always untrue" to "Almost always true", with "Does not apply" as an additional answering option. In our data, the "Does not apply" option was more frequently used on a few items, compared to the other items, one example being "Likes the crunching sound of leaves in the fall". However, these items were not indicated as candidates for removal in the item-scale reliability analyses and we therefore kept the items for further analyses. Some of the TMCQ items are unique for the TMCQ, but a majority of the items were adapted from the CBQ, the Hampton Individual Differences Questionnaire (Baker & Victor, 2001), the Childhood Temperament and Personality Questionnaire (Victor, Rothbart & Baker, 2003), and lastly, from the Berkeley Puppet Interview (Ablow & Measelle, 1993; Hwang, 2004). The TMCQ is the last of the questionnaires from the Mary Rothbart Lab to be translated into Swedish.

Although good convergent validity has been reported for the CBQ, from which the majority of items were adopted (Rothbart et al., 2001), no validity data have been reported for the caregiver version of the TMCQ. However, the study by Kotelnikova et al. (2016) discusses that temperament assessed via the TMCQ is related to important developmental outcomes such as emotion regulation, and emerging symptoms of psychopathology (e.g., Kotelnikova, Mackrell, Jordan, & Hayden, 2015; Simonds, Kieras, Rueda, & Rothbart, 2007), thus supporting the predictive validity of the TMCQ.

The Sensitivity to Punishment and Sensitivity to Reward Questionnaire for Children (SPSRQ-C)

The SPSRQ-C (Colder et al., 2011) was elaborated from The SPSRQ (Torrubia, Ávila, Moltó, & Caseras, 2001), which is the adult, self-report version of the questionnaire. The SPSRQ-C is a 33-item caregiver questionnaire, designed to assess seven subscales of the BAS, the FFFS and the BIS according to the r-RST (see Table 2).

Table 2.
Temperamental factors and sub-dimensions of the SPSRQ-C.

Temperamental Factor	Sub-dimension	Number of Items	Cronbach's alpha
BAS*	Drive	5	.70
	Impulsivity/Funseeking	6	.73
	Responsiveness to Social Approval	4	.71
	Sensory Reward	2	.52
FFFS*	Fear/Shyness	9	.65
BIS*	Anxiety	5	.83
	Conflict Avoidance	2	.45

* Note: BAS: Behavioral Activation System, FFFS: Fight-Flight-Freeze system, BIS: Behavioral Inhibition System.

Responses are made on a 5-point scale from "Strongly disagree" to "Strongly agree". The SPSRQ-C items are formulated as such: "Your child is afraid of many things compared to other children their age" (23), "Your child is often afraid of new or unexpected situations" (12), "Your child has a lot of difficulty ending a fun activity" (20), and "Your child sometimes does things for quick reward" (22). Items are divided into seven subscales, Impulsivity/Fun-seeking (6 items, = .75), Drive (5 items, = .60), Responsiveness to Social Approval (4 items, = .67), Sensory Reward (2 items, = .68), Fear/Shyness (9 items, = .83), Anxiety (5 items, = .67), and Conflict Avoidance (2 items, = .39). Subscales Conflict Avoidance and Sensory Reward contain a mere 2 items each and have in previous research been suggested candidates for removal (Torrubia et al., 2001).

The questionnaire aims to assess punishment sensitivity (BIS + FFFS) and reward sensitivity (BAS). Studies have shown satisfactory internal consistency and test-retest reliability for both the punishment sensitivity and the reward sensitivity factors (O'Connor et al., 2004; Torrubia et al., 2001). Research has found punishment sensitivity to be positively related to Eysenck's neuroticism dimension, negatively related to Eysenck's extraversion and un-related to Eysenck's psychoticism. Reward sensitivity has been found to be positively related to Eysenck's extraversion and neuroticism, moderately related to Eysenck's psychoticism, and positively related to the Eysenck's Impulsiveness scale.

The SPSRQ is recurrently used in clinical research, and it is also well-validated against different tests on sensitivity to punishment and reward, such as the Card Arranging Reward Responsiveness Objective Test (CARROT; Powell, Al-Adawi, Morgan, & Greenwood, 1996), and the Q-TASK (Newman, Wallace, Schmitt, & Arnett, 1997). Results from such studies have shown good validity for the questionnaire (e.g., Fuentes et al., 2014; Kambouropoulos & Staiger, 2007; Luman, van Meel, Oosterlaan, & Geurts, 2012; Lyvers, Karantonis, Edwards, & Thorberg, 2016; Moreno-López, Soriano-Mas, Delgado-Rico, Rio-Valle, & Verdejo-García, 2012).

Subscales included in our studies

When temperamental disposition is to be examined in research, an initial decision has to be made between using the whole temperamental factor, including all its subscales, and using unique subscales as representatives for the factor. Both ways of action have their challenges. For example, research has concluded that although the different components of effortful control work as an integrated system, they appear to develop and function in unique ways (e.g., White et al., 2011). Also, assessing reward sensitivity through questionnaires (rather than using physiological measures such as the event-related potential [ERP], or other brain-activity observation techniques) has been questioned by some researchers, since the different aspects of reward sensitivity are diverse and independent of each other (Carver, 2004; Carver & White, 1994). Although we used the same sample and aimed to study temperamental influences on risk-taking and decision-making in both study 2 and 3, to a large extent we used different subscales for the two studies. This decision was made due to the fact that the computerized tests have a different setup, and because we were interested in either reactive or regulative aspects of temperament depending on the test. We also believed it necessary to use different aspects of EC since the tests had different setups.

Fear and anxiety are both part of the punishment sensitivity system, however, the r-RST considers them to be distinct where fear equals defensive avoidance and anxiety defensive approach. We chose Fear as the subscale of punishment sensitivity in both study 2 and 3, because of its reactive nature.

In the second study, we were not interested in the effect of individual differences in the general sensitivity of the BAS. Instead, we aimed to understand risk-taking as a result of the interplay between three observable traits that can be considered representative of the three temperamental systems. As a representative for reward sensitivity, we chose to use the Drive subscale. Drive was chosen due to its implied movement towards a desired goal. We judged individual differences in drive to be highly relevant for the criterion risk-taking behavior assessed in the second study. Importantly, drive does not necessarily imply failed constraint, which may be confounded as low self-regulative capacities. Conversely, as we were interested in reactive approach in the third study, we used the Impulsivity subscale as a measure for reward sensitivity, as it represents reactive under-control (the tendency to act with little forethought; DeYoung et al., 2007), thus indicating high reward sensitivity and an easily activated BAS.

According to Rothbart the different EC subscales are defined as follows: “The capacity to perform an action when there is a strong tendency to avoid it” (Activation Control), “The tendency to maintain attention focus upon task-related channels” (Attention Focusing), and “The capacity to plan and to suppress inappropriate approach responses under instructions or in novel or uncertain situations” (Inhibitory

Control). Their different qualities make it imperative to investigate their effects on behavior individually (Paunonen, 1998). In study 2 we used the subscale Activation Control as a measure of EC. Activation Control was selected for two main reasons: (1) control of risk-taking, as assessed in study 2, required children both to inhibit a dominant response and to actively engage in another, which is a capacity that defines activation control; and (2) since Activation Control involves the capacity to make a subdominant response, it would seem to be less easily confounded by purely reactive antagonistic processes than, for example, Inhibitory Control. In study 3 we used a combined measure of Inhibitory Control and Attention Focusing to get a measure of EC. Activation Control was not included in this measure, since doing so would make the factor less homogenous and more difficult to interpret.

Risk-taking measures

To operationalize risk-taking, we used two computerized tests: The Balloon Analogue Risk Task for Youth (BART-Y; Lejuez et al., 2007), and The Risky Decision-Making Test (RDMT; Bengtsson, Nystrom, & Van de Weijer, 2016). While the BART-Y is a well-validated instrument often used in research, the RDMT was programmed for the purpose of the current thesis. BART-Y measures risk-taking in a situation that engages hot processes (previously described in this thesis on p. 34), since the children are continuously informed about their earnings and what reward they have earned thus far. The RDMT on the other hand, predominately involves cold deliberate processes since no feedback is given to them during the test about how many stars they have earned.

The Balloon Analogue Risk Task for Youth (BART-Y)

The BART-Y is a computerized test of risk-taking tendencies in children. The youth version is an elaboration of the Balloon Analogue Risk Task (BART; Lejuez et al., 2002). The BART-Y stages a conflict situation in which the child needs to balance the chance of reward and the risk of loss. The child is seated in front of a computer screen displaying a red balloon and a reward meter (see Figure 1).

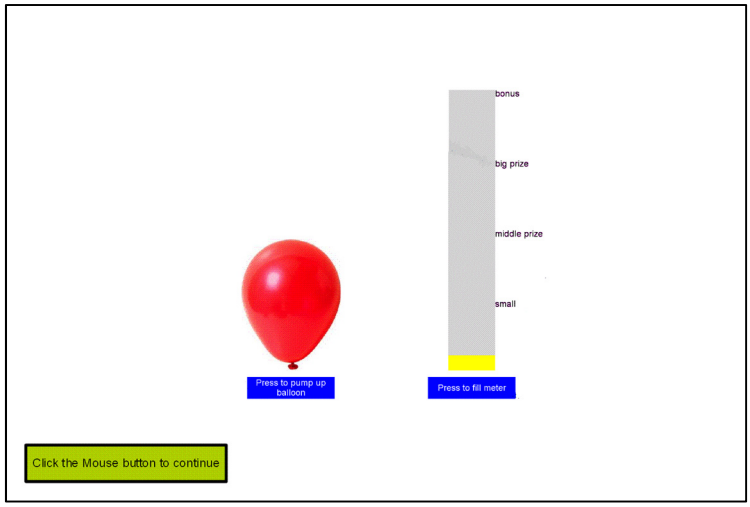

Figure 1. Screen caption of the BART-Y.
Note: The children click on the blue banner below the red balloon, and with each click the balloon expands a little. After a preferred amount of clicks, and before the balloon explodes, the child has the option of pressing the blue banner under the reward meter (right), to collect his/her points. The yellow part of the meter (collected point) will grow a little each time the meter is filled, thus displaying how much earnings the child has and if a reward level has been reached.

By clicking the computer mouse, the child can inflate the balloon. Each click inflates the balloon a little more and also earns the child one point. At any preferred moment in a trial, as long as the balloon is still whole, the child can collect the earned points in a reward meter by pressing a button on the screen. However, the balloon will explode after a randomly determined number of pumps, and if the balloon explodes before the points have been collected, all points for that balloon will be lost. Each new pump thus entails a potential risk of not obtaining the desired award. Every time the balloon explodes, or the child decides to fill the reward meter, a new balloon will appear on the screen. The number of trials (i.e., new balloons to pump) is fixed (30), and each child has to wait for his or her reward until the test is finished. The standard outcome measure for risk-taking in the BART is the adjusted average pump count studies (the average total number of pumps on trials in which the balloon did not explode; Lejuez et al., 2007; Lejuez et al., 2002).

The reliability of the BART has been established across a range of conditions and samples, revealing strong reliability (> 0.7) within sessions, as well as when comparing scores across all three blocks (i.e., split-third reliability). Adults demonstrate modest increases in risk-taking across blocks, while adolescents tend to reduce risk-taking from the first to the third blocks (White, Lejuez, & deWit, 2008). Studies suggest that risk-taking on the BART has adequate test-retest stability (White et al., 2008).

Hence performance on one occasion is likely to be representative of an individual's performance on other occasions even across days.

When examining the validity of the BART, it has shown significant relation with the self-reported occurrence of addictive, health, and safety risk behaviors (Lejuez et al., 2007). Riskiness on the BART has also been found to correlate with self-report measures of risk-related constructs and occurrence of real-world risk behaviors (Xu, Korczykowski, Zhu, & Rao, 2013), with measures of sensation seeking and impulsivity, and also with deficiencies in behavioral constraint (Lejuez et al., 2002). Reports on the psychometric properties of the BART-Y have established that riskiness on the BART–Y is associated with greater risk-taking behaviors in real-life, even when controlling for variables such as demographics and self-reported disinhibition, thus suggesting significant incremental validity (Lejuez et al., 2007). As for criterion validity, BART-Y scores have been related to number of risk-taking behaviors (Aklin et al., 2005). Research has established a strong link between the BART-Y and alcohol use (MacPherson et al., 2010), substance use (Aklin, Lejuez, Zvolensky, Kahler, & Gwadz, 2005), and risky sexual behavior (Lejuez et al., 2004). Results persist when controlling for demographic variables, impulsivity, and sensation seeking (Aklin et al., 2005; Lejuez et al., 2007).

Most of the children in our studies enjoyed playing the BART-Y, since it was an exciting test, visually attractive, and easy to comprehend.

The Risky Decision-Making Test (RDMT)

Incentive contexts are likely to affect both the decisions children make in risky situations and the speed with which they make these. The RDMT (Bengtsson, Nystrom, & Van de Weijer, 2016) was developed to test hypotheses derived from r-RST regarding how temperament and incentive-related contextual factors jointly determine children's risky decisions. The test makes it possible to study the effect of systematic variation of potential gain, potential loss, and conflict between these two factors on decision speed and willingness to engage in risk-taking. Risk-taking is operationalized as opting the response alternative with uncertain outcome in favor of the competing alternative with certain outcome. The ability to make room for deliberation (i.e., how much room there is for deliberation before the decision is reached), is operationalized as the increase or decrease of decision speed in situations of conflict.

We programmed this computerized test task using E-prime version 2.0 (Schneider, 2002), and responses were registered on a Cedrus response box (RB-730, Cedrus Corporation®). The test task is based on the traditional coin-flipping practice *Heads or Tails,* which has only two possible and equally likely outcomes (50/50 risk of

losing/chance of winning in each trial). The objective is to decide whether to take the chance of winning the number of stars displayed (*Yes*) or not to risk losing the number of stars simultaneously displayed (*No*) (see Figure 2).

Figure 2.
Screen caption of the RDMT.

In each of the 64 trials (16 possible combinations of stars to win or lose, presented randomly in 4 blocks), see Table 3, the number of stars that could be won (0, 1, 2, or 3) in the trial was presented to the left on the screen and the number of stars that could be lost (0, 1, 2, or 3) was presented to the right. The sentences "You can win" and "You can lose" appeared in text above the two stimulus sets. The question "Do you want to play?" could be read in the middle of the screen, below the two sets of stars. Children responded by pressing the corresponding key on the response box. When a response key was pressed, a new trial was initiated, and this proceeded until the game ended.

Table 3.
Experimental conditions arranged from Low (0) to High (3) in terms of Gain, Loss and Conflict value.

Gain value	Loss value	Conflict value
0 (0-0; 0-1; 0-2; 0-3)	**0** (1-0; 2-0; 3-0; 0-0)	**0** (3-0; 0-3)
1 (1-0; 1-1; 1-2; 1-3)	**1** (0-1; 1-1; 2-1; 3-1)	**1** (3-1; 2-0; 0-2; 1-3)
2 (2-0; 2-1; 2-2; 2-3)	**2** (0-2; 1-2; 2-2; 3-2)	**2** (3-2; 2-1; 1-0; 0-1; 1-2; 2-3)
3 (3-0; 3-1; 3-2; 3-3)	**3** (0-3; 1-3; 2-3; 3-3)	**3** (0-0; 1-1; 2-2; 3-3)

Note. The first figure in the parentheses indicates the number of stars to win and the second figure the number of stars to lose in each experimental condition.

To avoid making the motivational context dependent on children's behavior, they did not receive feedback regarding the actual outcome of each trial; they only received feedback on how many stars they had won at the end of the task. This made the RDMT quite different from the BART-Y, where the children could keep track of

their collected earnings throughout the entire test. Responses were registered on a Cedrus RB-730 response box®. Decision-making time and quality of decision (Yes, No) were recorded for each child. In each trial, response time (RT: milliseconds) and decision (Desire to gamble: yes = 1, no = 0) were registered.

Conflict was operationalized as the amount of conflict between potential wins and losses, that is, conflict is high when the pros and cons for the different response options are equal or almost equal in magnitude, and low when one of the response alternatives is clearly more attractive than the other. We also studied Gain value (the possible gain to be made in a certain trial), and Loss value (the possible loss to be made in a certain trial). In Table 3, the star combinations have been grouped and arranged into contextual variables (conflict and possible wins or losses). In star combinations with the highest conflict (C3), the number of stars that could be won was equal to the number of stars that could be lost by gambling.

Collecting our data, the RDMT was administered on a PC laptop with an 18.5'' screen. The RDMT was always presented as the first test task to the participants. Before the test began, the child was given standardized instructions, followed by eight practice trials. If the child displayed signs of not understanding the instructions (e.g., pressing the same key repeatedly without reflecting, hesitant behavior, or verbalizing insecurity about what to do), the instructions were repeated once before the test began. Each session with the RDMT lasted typically 10 minutes. Although most participants seemed content and motivated during the test session, the RDMT task was perceived as a bit repetitive and not very exciting by some children.

The other tests discussed in this thesis, such as the BART-Y (Lejuez et al., 2002), the IGT (Bechara, Damasio, Tranel, & Andersson, 2005), and the CCT (Figner, et al., 2009), are well-validated measures of risk-taking. However, there are some central features of the RDMT that distinguishes it from the other risk-taking tests. To begin with, the children does not get feedback on their performance in the RDMT, which likely makes it a test that predominately measures cold cognitive processes, based on deliberation and logic. Second, the RDMT provides data on the variation in deliberation time (decision speed) across trials, involving different amounts of risk. Lastly, the RDMT focuses systematically on the dimension of conflict in different combinations of potential gains and losses, while conflict is not specifically addressed in the other risk-taking tests described in this section.

Study I.

A Psychometric Evaluation of the Temperament in Middle Childhood Questionnaire (TMCQ) in a Swedish Sample.

Aims and predictions

The purpose of the study was to examine the psychometric structure of a translated version of The Temperament in Middle Childhood Questionnaire (TMCQ), in a Swedish sample. Although elaborated from several well-validated instruments, research reports on the psychometric properties of the TMCQ have been quite limited and users of the test have been referred to an unpublished dissertation (Simonds, 2006), and a research poster displaying reliability measures for a computerized version of the test (Simonds & Rothbart, 2004). However, in a recent study by Kotelnikova et al., (2016), higher and lower order factor analyses were performed on TMCQ data, and the questionnaire in its current format was strongly challenged. In the Kotelnikova study, all 17 subscales from the TMCQ were analyzed. Results yielded a four-factor structure bearing little resemblance to the structure proposed by Simonds and Rothbart (2009), and the authors recommended a vast elaboration of content to make it a useful tool for measuring temperament. Their results might indeed indicate that the TMCQ in its current form is an inappropriate measure of temperament. However, as a great proportion of the scale items were excluded prior to the authors' conducted the higher order factor analysis, a different final factor solution is almost to be expected.

Since previous reports on the psychometric properties of the TMCQ have been sparse and inconsistent, we wanted to further analyze the qualities of the questionnaire. Furthermore, we aimed to validate the TMCQ's ability to measure punishment and reward sensitivity as formulated by the r-RST, and measured through the Sensitivity to Punishment and Sensitivity to Reward Questionnaire for Children (SPSRQ-C). We hypothesized that: (1) our Swedish translation of the TMCQ would be a valid and reliable instrument for measuring temperament during middle childhood; (2) the factor structure of the Swedish translation of the TMCQ would be consistent with the three factors defined in Rothbart's theory on temperament; (3) the punishment sensitivity subscales (NA – BIS/FFFS) would be significantly correlated with each other, and the reward sensitivity subscales (SU – BAS) would be significantly correlated with each other; and (4) no significant correlations would be found between punishment sensitivity subscales and reward sensitivity subscales.

Method

Participants and procedure

The sample consisted of 157 middle-schoolers, *m* = 9.87 years, *SD* = 0.68 (46% girls), from eight schools. Forty-two percent of the approached schools and 50.1% of the concerned families accepted participation. Participating schools were located in the southwest of Sweden, and since the questionnaires were in Swedish, areas where foreign speaking parents constituted a minority were preferred. A closer inspection of the schools that accepted participation revealed that they were situated in either high or middle socioeconomic status areas. The rate of participating families varied greatly between schools (between > 80% and < 20%). Schools that were located close to the university showed the lowest participation rates, likely due to frequent approaches from researchers. Once the schools and the families had accepted participation, the TMCQ and the SPSRQ-C were filled in at home by the caregivers and sent back to school in a sealed envelope, together with consent forms.

Results

Internal consistency coefficients were generally satisfactory for the TMCQ subscales, ranging between .64 and .89. Inspection of the mean scores indicated that Soothability and Inhibitory Control were the most endorsed qualities, while Discomfort and Fear were the least endorsed. Several significant gender differences were found; girls were scored higher on Discomfort, Fear, Low Intensity Pleasure, and Perceptual Sensitivity.

Initial CFA (confirmatory factor analysis) model fit-values of the proposed three-factor solution can be considered sufficient but not excellent. Internal consistency for the temperament subscales was good, all but one value surpassing = > .70. A principal component analysis (PCA) generated three factors with eigenvalues greater than 1.0 (4.39, 2.66, 1.99), together explaining 64.66% of common variance. Overall, results presented a solution almost identical to the factor solution proposed by Rothbart, where the first proposed factor equals NA, the second equals SU and the third proposed factor equals EC, see Table 4.

Table 4.
Factor loadings and communalities for the three-factor PCA on the TMCQ.

Subscale	Component			Communalities
	1	2	3	
Soothability	-.84			.73
Sadness	.84			.35
Discomfort	.80			.69
Anger/Frustration	.77			.69
Fear	.66			.55
High Intensity Pleasure		.78		.62
Activity Level		.72		.59
Impulsivity	.39	.71		.73
Shyness		-.55		.35
Perceptual Sensitivity			.79	.72
Low Intensity Pleasure			.78	.61
Activation Control	-.45		.63	.65
Inhibitory Control	-.30	-.52	.61	.74
Attention Focusing	-.49	-.39	.52	.66

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization. Rotation converged in five iterations.
Note: Loadings displayed > .30.

To examine convergent and discriminant validity, correlations were computed between the punishment sensitivity factors (BIS, FFFS, NA) and the reward sensitivity factors (BAS, SU) from both questionnaires respectively. With respect to convergent validity, results showed that the punishment sensitivity factors of the two questionnaires correlated moderately but significantly with each other, indicating a linear relationship between factors and acceptable convergent validity for the TMCQ. The same was true for the reward sensitivity factors. Unexpectedly, in discriminant validity analyses, NA correlated significantly with the BAS, and a small negative correlation was also found between SU and the BIS/FFFS, see Table 5.

Table 5.
Pearson product-moment correlations (*r*) for temperamental factors from the TMCQ (in bold) and the SPSRQ-C.

	BIS/FFFS	**SU**	BAS
Negative Affectivity	.631**	-.044	.296**
BIS/FFFS	1	-.252**	.111
Surgency		1	.531**
BAS			1

** Correlation is significant at the 0.01 level (two-tailed).

Discussion

This study provided preliminary support for the reliability and construct validity for the TMCQ in a Swedish sample, suggesting that the TMCQ is possible to use in research on temperament. Results for discriminant validity were not entirely satisfactory, hence additional validity research studies need to be performed in order to establish validity for the TMCQ. Despite that the questionnaire in its current format has been questioned, we were able to show that the TMCQ measures temperament in a way that provides support for the three-factor model of temperament proposed by Rothbart. We also found the expected gender differences.

Overall, our data support the hypothesis that the NA and SU factors correspond to the r-RST factors of BIS/FFFS and BAS, indicating moderate construct validity for the factors. The results in study 1 also bring methodological support for the results in study 2 and 3. The positive correlation between NA and BAS can potentially be interpreted through the subscale Anger, which is included in the NA factor. Recent research suggests that anger is related to motivational tendencies of both the approach and avoidance systems (Watson, 2009). If this is true, then a small positive correlation between NA and BAS would be expected. A small negative correlation was also found between BIS/FFFS and SU. As BIS/FFFS comprises the subscale Fear/Shyness, and SU contains the subscale Shyness (reversed), this relationship could have been anticipated. We also checked for gender differences, and significant differences were found for the temperamental subscales Fear, Discomfort, Low Intensity Pleasure and Perceptual Sensitivity; girls were scored higher than boys. Girls were also scored higher on EC. Similar results have been found in many other studies on gender differences in personality (Else-Quest et al., 2006), thus providing additional support for the construct validity of the questionnaires. In regard of the large number of studies that have reached the same results, these findings thus may represent an overall better ability of girls to control inappropriate responses and behaviors than boys, rather than it being an effect of social and cultural norms.

Study II.

Temperamental Influences on Children's Risk-taking in Decision-making: A Dual Process, Multi-Level Analysis.

Aim and predictions

The aim of the present study was to examine risk-taking as a function of temperament by taking into consideration the potential three-way interaction between facilitatory reactivity, antagonistic reactivity, and inhibitory control. In general, previous studies have focused their attention on the influence of one temperamental trait at the time and not on a combination of traits, missing out on crucial information. According to Rothbart's theory, SU, NA, and EC are interdependent temperamental systems. They represent the operation of different temperamental systems, but hinge on each other for evolvement (Rothbart et al., 2000). Considering the Joint Subsystem Hypothesis, it can be assumed that a coinciding activation of the temperamental systems is what determines risk-taking (Corr & McNaughton, 2008). We therefore hypothesized that we would find an interaction effect between the temperamental traits fear, drive, and activation control on risk-taking behavior in children. Furthermore, we anticipated that the ability to control one's actions would serve as a protective factor against risk-taking in children with co-occurring high levels of drive and low levels of fear. In addition, we hypothesized that good activation control would help children high in fear to overcome their fearfulness and take more risks.

Method

Participants

The sample consisted of 67 fourth graders from three schools, located in the south-west of Sweden. Data from two children were excluded because of insufficient data-recordings (i.e., one child were unable to finish the test due to medical reasons, and for one child the response box failed to record data), leaving 65 children in the final sample (m = 10.59 years, SD = 0.30, 55% girls).

Measures

We used the caregiver questionnaires Temperament in Middle Childhood Questionnaire (TMCQ; Simonds & Rothbart, 2004) and the Sensitivity to Punishment and Sensitivity to Reward Questionnaire for Children (SPSRQ-C;

Torrubia, Ávila, Moltó, & Caseras, 2001), to assess Fear, Drive and Activation Control. To measure risk-taking, we used a well-established computerized test game, the Balloon Analogue Risk Task for Youth (BART-Y; Lejuez et al., 2007). The BART-Y stages a conflict situation (to inflate or not to inflate a balloon) in which the participant has to balance between taking the chance of reward and avoiding the risk of loss (see Figure 1).

Results

Bivariate correlation revealed no significant relations between Activation Control, Fear, and Drive. A 2 x 2 x 2 ANOVA was performed to examine how risk-taking was affected by the between-subjects scales Drive, Fear and Activation Control. Median split independent variables were computed in order to perform the analysis. The analysis revealed a highly significant interaction effect of the three independent variables, see Table 6.

Table 6.
Effects of Drive, Fear, and Activation Control on risk-taking.

Source	df	F	p
Activation Control	1	5.84	.02
Fear	1	0.13	.72
Drive	1	0.18	.68
Fear * Drive	1	0.39	.54
Activation Control * Fear	1	1.57	.22
Activation Control * Drive	1	4.8	.03
Activation Control * Fear * Drive	1	9.54	.003

Follow-up *t* tests revealed that children with low activation control and low fear increased their risk-taking significantly with drive (M = 41.44, SD = 16.99 vs. M = 20.36, SD = 9.5; p = .006). The opposite result was found in fearless children with high activation control (M = 6.6, SD = 2.5 vs. M = 15.84, SD = 6.47; p = .04), see Figure 3.

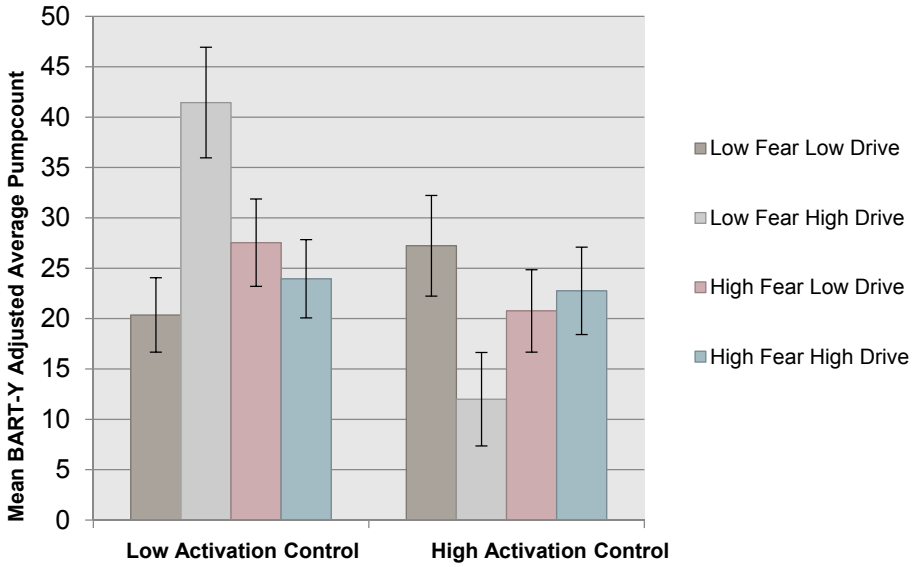

Figure 3.
Risk-taking behavior (means and standard error of the means) for children with different combinations of drive, fear, and activation control.

Children with high drive and low levels of activation control received the highest risk-taking index of all the children in the sample. Fearless children, high in drive but with high levels of activation control, were much more cautious, receiving a lower risk-taking index. For these children, activation control appears to function as a brake that allows them to inhibit their behavior.

Discussion

We hypothesized that the approach children adopted in the risk-taking test would be determined by the interaction between their facilitatory and antagonistic temperamental reactivity and their ability to control behavior voluntarily. Our results are consistent with this hypothesis, and hence, relatively fearless children with high drive used a high-risk approach if they had poor activation control, and a precautious approach if they had good activation control. The concept of activation control refers to the ability to activate a subdominant response over a more dominant alternative. There is little prior research on this functional aspect of EC and we know of no previous studies on the role of activation control in risk-taking. However, within neuropsychological research, several studies on the relation between prepotent response inhibition and risk-taking have been performed (Johnson, Tharp, Peckham,

Sanchez, & Carver, 2016; Kräplin et al., 2014; Noël, Bechara, Dan, Hanak, & Verbanck, 2007). Prepotent response inhibition is defined as the deliberate suppression of dominant, automatic, or prepotent responses (Miyake et al., 2000). Such studies indicate that deficits in this function are related to heightened levels of risk-taking behavior (Miyake et al., 2000; Kräplin et al., 2014).

Our findings provide a differentiated picture of how facilitatory and antagonistic temperamental reactivity, together with more intentionally controlled constraint, influence risk-taking. In our sample, risk behavior increased with dispositional drive in the group of children with low constraint (low fear in combination with low activation control). Thus it seems that well developed deliberate control over behavior can compensate for the potential negative consequences of low fear on risk-taking behavior. Consistent with prior research linking exuberant temperament to risk-taking behavior (Fox, Russo, Bowles, & Dutton, 2001; Lahat et al., 2012), children with this combination of temperamental characteristics (high drive, low fear, poor activation control) showed the strongest risk-taking tendencies. Identifying the temperamental qualities that affect risk-taking can help identifying individuals in danger of developing maladaptive behavior. Research has shown that aspects of EC can be improved through cognitive training. If we can take preventive action and help the children at risk improve their EC abilities, this might elevate their chances of becoming more successful in their academic and social life, and also lower the risk of them engaging in risk-taking behavior.

Study III.

Temperamental Qualities Moderate Incentive-related Contextual Influences on Children's Risk-taking Decisions.

Aim and predictions

Risk-taking situations typically provide opportunities for an individual to obtain a desired reward, but also potential harm or danger (Geier & Luna, 2009). Thus, there are elements of uncertainty and conflict in risky situations that call for reflection and serious consideration of costs and benefits before engaging in action. Temperament affects risk-taking in children, and especially the exuberant disposition has been linked to risk-taking (Degnan, Almas, & Fox, 2010; Lahat et al., 2012; Polak-Toste & Gunnar, 2006). Performance in risk-taking situations will be influenced by one's sensitivities to incentives and threats, as well as one's capacity to deliberately and flexibly control these motivational dispositions. In many contexts risk-taking is

maladaptive and can lead to serious consequences for the individual. Children who frequently engage in risk-taking behaviors may cause serious harm to themselves and others. It is therefore important to identify young children who are prone to take risks, and also to understand how contextual factors influence their behavior (Eisenberg et al., 2009; Geier, 2013; van Duijvenvoorde et al., 2014).

In Study 3 we aimed to examine how temperamental qualities interact with incentive contexts in determining children's decisions to take risks. Risk propensity was measured through a computerized go/no-go task that we developed for this study. We wanted to study how children adjusted their decisions and decision speed in the test to changes in incentive conditions, as well as examine how children's temperament influenced the manner in which they modulated decision speed. We predicted that temperament traits would interact with contextual incentives in risk-taking. On the basis of the r-RST, we hypothesized that anticipated potential gains and losses would affect the alacrity to gamble differently, depending on the temperamental disposition of the child. We hypothesized that potential gain would promote the desire to gamble and speed up decisions, and that potential loss would reduce the desire to gamble and slow down decisions. Conflict was expected to slow down decision speed and promote conservative decisions. We further hypothesized that impulsive children would make quicker decisions, and more frequent decisions to engage in gambling, compared to less impulsive children, and that the difference between the responses of the low impulsive and the high impulsive children would increase with the size of the potential gain. Conversely, we anticipated that the fearful children would make slower decisions and more conservative decisions compared to the relatively fearless children, and that these effects would be strongest at high levels of potential loss and at high levels of conflict. Finally, we hypothesized that effortful control would facilitate slowed response and more conservative decisions.

Method

Participants

Participants were 157 third and fourth graders from eight schools, located in the southwest of Sweden (M = 9.87 years of age, SD = 0.67; 47% girls). Fifty percent of the asked families accepted participation in the study.

Measures

We used the TMCQ (Simonds & Rothbart, 2004) to assess Fear, Impulsivity, Inhibitory Control, and Attention Focusing. The questionnaires are described in detail earlier in this thesis below the heading: Temperament Questionnaires. The Risky Decision-Making Test (RDMT; Bengtsson, Nystrom, & Van De Weijer,

2016), was programmed using E-prime version 2.0, and administered on a PC laptop with an 18.5'' screen. Responses were registered on a Cedrus RB-730 response box (Cedrus Corporation, 2012). All 16 possible combinations of the number of stars to win (0–3) and the number of stars to lose (0–3) were presented randomly in four blocks, yielding 64 trials in total. In each of the 64 trials the children had to decide whether they wanted to take the chance of winning the number of stars displayed (Yes) or whether they preferred not to risk losing the number of stars simultaneously displayed (No; see Figure 2). The outcomes were equally likely; there was a chance of winning or losing 0, 1, 2, or 3 stars. The combinations of stars were grouped by possible gain (Gain value), possible loss (Loss value), and conflict between response alternatives (Conflict value).

Procedure

Caregivers reported on their children's temperamental qualities by filling out questionnaires at home. The questionnaires were sent back to the school in a sealed envelope. Children were then tested individually during a single session (30–45 minutes), in their own schools. After the test, the children received a reward.

Data-analysis

Hypotheses were tested using Linear Mixed Models (LLM), in SPSS 23. The models examined the joint fixed effects of temperamental variables and contextual variables on the dependent measures. The first LMM examined the fixed effects of three contextual variables (Gain value, Loss value, and Conflict value), and three temperamental variables (Impulsivity, Fearfulness, and EC), on decision speed. In an analogous LMM, we then examined the fixed effects of the same predictors on desire to gamble.

Results

Overall, incentive context influenced decisions in the predicted way and there were several significant interactions between temperament and incentive context, see Table 7. As anticipated, decision speed increased significantly with potential gain, see Table 8. This increase in decision was particularly strong in children with high impulsivity or low fear. Furthermore, decision speed generally decreased significantly with potential loss and amount of conflict. This was especially true for the fearful children. Furthermore, as anticipated, the desire to gamble increased with potential gain and decreased with potential loss. The decrease in desire to gamble as an effect of the size of potential loss was moderated by fearfulness and EC; the decrease was steeper in children with high fearfulness than in children with low fearfulness, and steeper in children with good EC than in children with poor EC. Lastly, the effect of conflict on

the desire to gamble was moderated by fearfulness and EC. Children low in EC or fearfulness increased their desire to gamble significantly with the amount of conflict involved in the decision, whereas, in children with high EC or fearfulness, the desire to gamble was unrelated to the amount of conflict involved in the decision.

Table 7.

Linear mixed effects analyses for temperament, response time and desire to gamble.

	Response time			Desire to gamble		
Variable	*t*	Estimate	*SE*	*t*	Estimate	*SE*
Fixed effects:						
Gain (G)	-6.85***	-.013	.002	74.64***	.229	.003
Loss (L)	6.47***	.012	.002	-53.20***	-.163	.003
Conflict (C)	11.24***	.024	.002	1.29	.005	.004
Impulsivity (I)	-.019	-.005	.003	3.36***	.117	.035
Fearfulness (F)	0.084	.015	.018	1.85	.023	.042
Effortful Control (EC)	0.16	.002	.012	2.76**	.044	.016
GxI	-2.54*	-.01	.004	-6.70***	-.044	.016
GxF	2.52*	.006	.003	-1.57	-.007	.004
GxEC	0.15	.0002	.002	-3.07**	-.009	.003
LxI	-0.06	.0002	.004	1.18	.008	.007
LxF	-0.39	-.001	.003	-3.33***	-.014	.004
LxEC	0.13	.0002	.002	-3.81***	-.011	.003
CxI	-1.33	-.006	.005	-1.21	-.009	.008
CxF	-0.61	-.002	.003	-3.02**	-.015	.005
CxEC	0.51	.001	.002	-3.59***	-.012	.003
Random effects:						
Subject		.021	.003		.027	.003
Residual		.042	.001		.117	.002

*p < .05. **p < .01. ***p < .001.

Table 8.

Means, SD, and Zero-order Correlations for temperament variables, response time, and desire to gamble.

Variable	1.	2.	3.	4.	5.
Effortful Control					
Impulsivity	-.66***				
Fearfulness	-.07	.04			
Response time	.11	-.15	.09		
Desire to gamble	-.18*	.21*	-.05	-.20*	
M (SD)	3.60 (0.65)	2.57 (0.62)	2.43 (0.73)	3.16 (0.15)	0.57 (0.17)

Note. Ratings of temperamental variables could range from 1 to 5. Response time is in LOG milliseconds and Desire to gamble was coded as yes = 1, no = 0. *p < .05. **p < .01. ***p < .001.

Discussion

On the basis of r-RST, we anticipated temperamental qualities to interact with incentive-related contextual factors in influencing children's risky decision-making, and results from the current study provide further support for this relationship. We found strong support for our hypothesis that incentive context influences children's decisions: Both the desire to gamble and the speed with which the decision was reached increased with the size of the potential gain and decreased with the size of the potential loss. We also found support for our hypothesis that conflict would have a decelerating effect on decision speed.

We found that impulsivity influenced children's responses to potential gain, which is consistent with the r-RST. First, increase in decision speed as a function of potential gain was steeper in impulsive children than in less impulsive children. Our results thus suggest that this quality may influence their behavior at a greater extent in situations where they are attracted to big rewards. Moreover, the children's desire to gamble also correlated positively with their impulsivity, in which the size of the potential gain was less important for the high impulsive children than for the low impulsive children. Thus, impulsive children occasionally gambled even in situations when there was nothing or very little to gain. This finding illustrates the often noted, under-control or dysfunctional aspect of impulsivity (Dickman, 1990; Smillie, Jackson, & Dalgleish, 2006). Impulsive children seem to have a motivational set that facilitates quick approach to big rewards, but undermines their capacity to take potential danger into due consideration (DeYoung, 2011).

The fearful children displayed a reduction in the desire to gamble at high levels of potential loss, and also at high levels of conflict (uncertainty about the correct response). These results are consistent with the notion that fearfulness reflects punishment sensitivity and an easily activated avoidance system (McNaughton & Corr, 2008). Furthermore, the results suggest that in contexts where there are particularly strong reasons to be cautious, fearfulness has a repressive effect on children's risky decision-making. As anticipated, EC abilities moderated incentive-related contextual effects on children's decisions in a similar way to that of temperamental fearfulness. Our results indicate that good EC restrains the desire to gamble, especially when potential loss or conflict is high. These findings support proposals that EC functions as a defensive behavioral control system that operates to prevent actions that may be disadvantageous or too risky.

General Discussion

This thesis addresses the influence of temperamental traits on risk-taking and decision-making in children. Risk-taking behavior during childhood is predictive of risk-taking later in development, and can lead to many maladaptive outcomes for both the individual, his or her environment and for society. Hence, it is important to know how behavioral traits influence risk-taking so that functional preventive action can be taken, supporting the individuals at risk. The most important contributions of this thesis are the conclusions that different factors of temperament may interact in risky decision-making, and that this process may be systematically affected by contextual incentives. Another significant conclusion is that EC abilities are of essential importance for adaptive decision-making in risky situations, which is important when trying to prevent maladaptive risk-taking behavior in children.

Risk-taking

As previously stated, risk-taking is a multidimensional concept that can occur within many different life domains (Blais et al., 2001). We studied risk-taking in the gambling domain, as measured by the BART-Y and the RDMT. Research has been able to establish that risk-taking in one domain shows little relation to risk-taking in other domains (Wang et al., 2016). Regarding the results from the Wang study, we cannot claim to have measured risk-taking behavior in general. Hence, we cannot tell for sure whether or not the risk-prone children in our study will engage in mountain climbing, deep sea diving, hazardous financial investments, cheating, shop-lifting, substance use, or any other form of risky behavior. However, previous research using the BART-Y has reported strong relations between scores on the BART-Y and several "real-life" risk-taking behaviors during adolescence, such as the use of alcohol and drugs (Aklin et al., 2005; MacPherson et al., 2010) and risky sexual behavior (Lejuez et al., 2004). Hence, it can be assumed that some of the risk-prone children in our data material might be in the danger-zone of developing maladaptive behavior.

Studies on risk-taking quite often focus on the adverse effects of risk-taking on development. However, some level of risk-taking might be beneficiary in certain situations; while some risks certainly don't pay off, some actually do. This seems to be especially true when exploring the relation between creativity and risk-taking. For

example, it has been argued that risk-taking is necessary when developing new and creative inventions (Chen, Podolski, Rhee, & Veeraraghavan, 2014), and that taking risks in organizations is important to reach innovation performance (García-Granero, Llopis, Fernández-Mesa, & Alegre, 2015). College students who take risks and engages with the course material in creative ways, have been found to develop their critical thinking skills better than other students (Wintrol & Jerinic, 2013). A study on risk-taking among athletes found several high risk groups among the elite athletes, and that the degree of inclusion in the elite sports system correlated positively with risk acceptance (Schnell, Mayer, Diehl, Zipfel, & Thiel, 2014). The athletes who were very focused on their performance were particularly willing to take risks in the social domain. Hence, it seems that there are benefits in some form of controlled risk-taking. This might imply that in certain situations, parents and teachers could actually encourage the fearful children to take more risks, and be more creative, to increase their chances of successful outcomes in areas important to them.

Risk-taking, context and temperament

Much research on risk-taking has aimed at studying the relation between one single temperamental system, and risk-taking, which does not allow a fine-grained analysis of the manner in which temperamental dimensions interact. In this thesis, we aimed to study the interactive influence of temperamental systems on risk-taking behavior in children, and also how risk-taking is affected by contextual incentives. This has been studied before by Figner and Weber (2011) who proposed that situation and context interact with individual traits in risk-taking. Similar thoughts can also be found in the JSH (Joint System Hypothesis), a modern addition to the r-RST), which suggests that the temperamental systems work together in motivated behavior (Corr, 2002).

According to both Figner and Weber and the JSH, it is unlikely that one temperamental system alone would be responsible for all individual risk-taking tendencies. The second study in this thesis is unique since it focuses on the relative influence of temperamental traits from the three temperamental systems on risk-taking. Results from study 2 suggest that it is the combined activation of all three temperamental systems that will affect the risk-taking tendencies in a child. Furthermore, interaction between systems has also been proposed by Derryberry and Rothbart (1997). The results are quite intriguing; on their own, only EC was significantly related to risk-taking, but together the three systems of temperament show a strong relation to risk-taking behavior. The third study of this thesis brings an even deeper understanding to the relationship between temperament and risk-taking. The study provides support for the notion that temperament traits affect the way children react to the potential gains and losses of their decision, in risk-taking situations; that is, the relation between temperament and risky decision-making is

modulated by contextual incentives. Hence, study 3 supports the results from the study by Figner and Weber (2011): individual traits interact with contextual variables in risk-taking.

Our results imply that risk-taking is complex and that it cannot be explained by simple, direct relationships, which has generally been the focus of previous research where risk-taking usually has been explained as being the behavioral effect of impulsivity and/or lack of self-regulative capacities. An additional conclusion about risk-taking that can be drawn from study 2 and 3 is that aspects of EC may have a profound effect on children's risk-taking behavior; for example, even if you are a highly active, fearless child with strong motivational approach tendencies, you can still succeed in avoiding risk-taking behavior if you are skilled in controlling your actions. Furthermore, a well-developed deliberate control restrains the desire to take risks, especially when potential loss or conflict is high, which can moderate potential negative effects of other temperamental traits on risk-taking behavior. This is hopeful, since many studies suggest that aspects of self-regulation and other EFs can be improved by training (Karbach & Kray, 2009; Klingberg et al., 2005; Motes et al., 2014; Rueda et al., 2005; Thorell et al., 2009). Hence, our studies might have important implications for risk-taking prevention.

Temperamental factors and subscales

An important issue in studying human temperament is the question of whether or not a strong dispositional reaction in one system, rather is about a weak reaction in another system. In our studies, this would implicate that children interpreted as high in drive and/or impulsivity rather were low on anxiety and fear. With the use of brain scanning techniques (Kennis et al., 2013; McNaughton & Corr, 2008), or the measuring of hormonal levels (Corr & McNaughton, 2008), activation of the different systems can be separated from one another. However, due to the complexity of such methods, they can be used only in a limited amount of clinical research. Temperamental questionnaires are easily administered and the benefits of using questionnaires to assess temperament have been thoroughly investigated. As the SPSRQ is well-validated in neuro-imaging studies and against performance tests on sensitivity to punishment and reward (Kambouropoulos & Staiger, 2007), it can be claimed, that the SPSRQ seems to be able to distinguish between activity in the different systems.

In our studies, we decided to use subscales relevant to the research hypotheses, typically one from each factor, instead of using the broad and complex factors. The use of individual subscales in assessment, as opposed to using the broad punishment and reward sensitivity factors, has been recommended by previous research, partially

because it remains to be established if some traits in fact can hold both approach and avoidance tendencies (Carver, 2004). We based our decision to use individual subscales on the notion that the broad factors of temperament are too complex to provide a good measure of individual functions. That is, a person high in BAS functioning does not necessarily have equally high levels on all aspects of BAS. To use the factors thus could entail misleading data. Furthermore, we chose to use different subscales for the two studies. This was not a self-evident decision as the thesis would have been more consistent using the same subscales throughout the studies. However, since the computerized tests have a different setup, we were interested in either reactive or regulative aspects of temperament depending on the test. And hence we needed to use a variety of subscales.

Research has found that temperamental anger can be related to both approach and avoidance tendencies. In situations of threat, assertive action has been linked to anger/rage while non-assertive action has been linked to fear/frustration (Carver & Harmon-Jones, 2009; Cooper, Gomez, & Buck, 2008; Watson, 2009), and research has found support for the hypothesis that both positive and negative feelings can arise from the approach system (Carver, 2004). This notion has found further support in research whereas aggressive anger has been related to impulsivity (Hatfield & Dula, 2014; Levi, Nussbaum, & Rich, 2010). In the PCA of study 1 in this thesis, the Impulsivity subscale loaded most strongly onto the reward sensitivity factor, but also loaded onto the punishment sensitivity factor. Previous research has suggested impulsivity to be a multifactorial trait consisting of several behavioral subtypes (Evenden, 1999; Fineberg et al., 2010), which can explain this result. In our third study, we used the Impulsivity subscale as a measure for approach behavior, accordingly with the r-RST and Rothbart's theory. Indeed, Impulsivity showed strong approach tendencies in our data, and was closely related to risk-taking. It thus seems that although the Impulsivity scale loaded on both NA and SU, it is predominately a reward sensitive trait.

Temperament assessment in children

In the three studies of this thesis, different aspects of temperament are being measured. Due to biological development, personality traits expand and become increasingly differentiated and complex from infancy through middle childhood and adolescence. As the brain develops, children acquire new skills in cognition, language, and emotion, as well as new social and motor competences. Even though personality traits have shown some stability into adulthood, traits might relate to each other, and co-vary, differently during different phases of life (Shiner & Caspi, 2003). Furthermore, with age, individuals will have spent longer time under the influence of

their specific environments, making their own life experiences. Hence, it is important to have age-specific techniques when assessing personality.

We used two temperament questionnaires for all three studies: the SPSRQ-C and the TMCQ. While the SPSRQ-C is a well validated questionnaire often used in research, the TMCQ suffers from a scarcity of reports on its psychometric properties. The contribution of study 1 is that the results provide new data regarding its validity and factor structure. Results indicate that the factors are consistent with Rothbart's theory, when including the 14 CBQ variables, and excluding the three later elaborated TMCQ variables (Affiliation, Assertiveness/Dominance, and Fantasy/Openness). Although being temperamental traits in their own right, the three variables do not seem to be easily explained by Rothbart's three-factor model of temperament. Even if further validity studies still are necessary, our results indicate that the TMCQ might be a useful instrument in measuring temperament during middle childhood, with the ability to measure both punishment and reward sensitivity, and firmly grounded in temperamental theory as it is proposed by Rothbart.

In this thesis, all data on children's temperamental functioning are received through parental questionnaires. Parents possibly will be affected by their own values and focus of interest when answering questions about their children. They may, for example, provide an overly positive picture of their child. However, it has been suggested that the more we know a person, the less likely it is that we are affected by stereotypes in our judgements about that person (Weber & Crocker, 1983). With few exceptions, parents have the most experience with their own children, potentially putting them in the best position to report on the children's behavior (Else-Quest et al., 2006). Parental reports have also been proposed as better than teacher reports, as the teacher meets children in a group of peers where some individual differences tend to be magnified (Maccoby, 1990). However, parents have a smaller frame of reference than teachers and while parents might compare the child to siblings, teachers have the opportunity to make comparisons to a great sample of children. A combination of the two thus would be optimal.

There are other techniques available for studying temperament in children. A variety of methods offers possibilities to study individual differences in children with more validity than when only one method is being used. Previous research has made an effort to study temperament through observational studies, using measures such as the Behavioural Style Observational System (BSOS: Martin-Storey et al., 2009), or eliciting and rating of behavior in a laboratory environment (Majdandžić & van den Boom, 2007). In a laboratory setting, specific tasks and situations can be developed to observe children's behavior. Laboratory tasks have been created to assess individual differences in, for example, EC (Kochanska & Knaack, 2003) and behavioral inhibition (Kagan, Snidman, & Arcus, 1998). In some research, home observation

systems have been developed to assess individual behavioral differences (Buckley, Klein, Durbin, Hayden, & Moerk, 2002). A moderate convergence between parental questionnaires and laboratory observations has been found in studies observing temperament in children, but at the same time, a higher stability for questionnaires than for observations of temperament has been established (Majdandžić & van den Boom, 2007). This has been explained as due to the fact that parental perceptions are based on a large sample of daily experiences and that their view of the child is relatively resistant to change over time (Majdandžić & van den Boom, 2007).

Although a variation of tasks can be a strength in a study, it also has its challenges. For example, children might react differently in a laboratory setting than they would in a more familiar situation. As already mentioned, it can also be difficult for a temperament researcher to separate confounding differences in a child, such as low EC vs. impulsivity. Home observations are a time- and money-consuming method, partially because all video material must be thoroughly and reliably coded. Also, in creating scoring sheets, the researcher still has to be grounded in a certain theory and thus decide what behaviors should be coded. Since questionnaires are a practical research method, being easily administered, they were the preferred assessment method in our studies over other more complex, and costly, techniques, such as behavioral observations and laboratory measures.

Gender differences in temperament assessment

When studying temperamental dispositions in general, gender differences automatically come into focus. In some research traditions, such as social structural theory, the discussion about gender differences is controversial due to the view that gender differences only exist as a function of socializing processes, grounded in a gender stereotyped society. According to such research traditions, it is not possible to study constitutional differences since such differences do not exist and since socialization already starts in the womb. Other research traditions, such as evolutionary psychology, disagree with this view and recognize that there are gender differences that cannot be ascribed to socialization processes. As reported earlier in this thesis, some gender differences have been reported in temperamental research. Small gender differences have been found where girls have been rated as being more fearful and boys as more active. Relatively large differences have also been found between girls and boys regarding EC, where girls have had higher levels of self-regulative capacities than boys. Since most reports on children's temperament are made by either a parent or a teacher, results might be regarded as either true differences, or differences that emerge due to gender biased reporters.

From theory to practice

Besides the central conclusions in this thesis about the importance of individual traits and contextual factors on risk-taking, another conclusion is the importance of EC to development. In both study 2 and 3, we conclude that well-developed EC abilities provide a good protection against individual risk-taking tendencies. Indeed, it seems that with the ability to execute control over action, comes a good protection against a wide range of maladaptive outcomes. This is good news, since research suggests that EC abilities can be improved through cognitive training interventions (e.g., Karbach & Kray, 2009; Klingberg et al., 2005; Thorell et al., 2009; Titz & Karbach, 2014).

With knowledge comes responsibility, thus raising questions about how can we use this knowledge to help children at risk? As a first step, the child at risk needs to be identified. In a clinical setting, the use of questionnaires is a good way of establishing individual vulnerability factors such as anxiety, or insufficient self-regulative capacities. With an overview of an individual's temperamental functioning based on clinical assessment, individually adapted interventions can be planned and executed. However, in a nonclinical situation such as schools or day care facilities, questionnaires are not axiomatic, and thus a more everyday approach might be necessary. If we know from experience that a child is active, fearless and often ends up in trouble, then it would probably be a good idea to offer a cognitive training program to that specific child.

Some research has indicated that EC is predictive of the outcome of executive function training in general; the better initial EC, the more successful the training (Studer-Luethi et al., 2015). If this is true, then there is something of a catch-22 relationship between training and self-regulative functioning; the better the self-regulation, the better effects of training. However, the better the self-regulation, the smaller the need for such training, and hence, if you have low levels of control, you are also more likely not to benefit from training. More research is needed in the area of cognitive training interventions and how temperamental traits interact with the training methods.

Limitations and future research

It was hard work, trying to find schools that were willing to take part in our study. A lot of time and effort was put into trying to reach and inform principals and teachers, and to inquire if they wanted to participate. One reason for declining was that many schools received multiple similar inquiries each semester, making it impossible to accept every request. The most common reason for declining participation was that the school staff was already under heavy stress to make the schooldays work smoothly,

and in order to protect teachers and students from stressful situations they couldn't engage in any external projects. Hence, our sample was much smaller than was first anticipated, and power could have benefited from a greater sample size. This is especially true for study 1, which focuses on the psychometric properties of the TMCQ. There is lack of consensus about how to compute a priori sample size, and it has been argued that scientifically clear recommendations on the sample size for validation studies remain to be developed (Anthoine, Moret, Regnault, Sébille, & Hardouin, 2014). Hatcher (1994, p. 73) recommends a minimum subject to item ratio of at least 5:1 in EFA, and that 10:1 would be ideal. Although some argue that a 1:1 subject to item ratio can be sufficient (which is the ratio in study 1), it is far from the more generally recommended 5:1, and thus our study runs the risk of making the results too sample specific. A review study by Guadagnoli and Velicer (1988) proposes that using absolute minimum sample sizes, rather than subject to item ratios, is more relevant, and that a minimum sample size of 150 observations is necessary to obtain an accurate solution in factor analysis. In this view, our sample size would be sufficient. Another problem with our sample is that the same sample was used in all three studies of this thesis, which might endanger the generalizability of the results.

We chose not to study development in risk-taking performance. We aimed to study children during middle childhood and involving children of different ages would have entailed using additional measures of temperament than the TMCQ, which would have created difficulties when comparing data about the children's temperament. Furthermore, since we used computerized tests to assess risk-taking, involving children of various ages and levels of cognitive development would have entailed problems with interpreting data, as we know little of how the test functions during different stages of childhood. This is thus an area where there is still important research to be made.

Intelligence has been suggested by some to be related to aspects of cognitive functioning, such as for example working memory (Colom et al., 2008; Conway et al., 2010). However, the use of IQ tests on children is time-consuming and sometimes controversial, and was therefore never an option in the planning and execution of this thesis. Still, in future studies it would be interesting to add measures of IQ to see if differences in intelligence could modify how temperamental traits interact with risk-taking behavior.

Among the temperament questionnaires developed by Rothbart and her coworkers, TMCQ was the one that best fits the age of the participants in the current research, since it is adapted for children between 7 and 11 years of age. However, the TMCQ suffered from a shortage of reports on psychometric properties, and references to a manuscript in process failed to present published articles about the TMCQ. In this

thesis, the NA and SU factors are validated against punishment sensitivity and reward sensitivity factors. Further examining construct validity by comparing the factors individually using other instruments and another sample, is necessary for establishing TMCQ validity. For such purposes, it would be of great value for future studies to compare TMCQ data to observational measures such as the Behavioural Style Observational System (BSOS; Martin-Storey et al., 2009), or eliciting and rating of behavior in a laboratory environment.

It would be relevant for future research to aim at creating a greater understanding of how the different aspects of temperament relate to each other. Results from previous research regarding approach and avoidance tendencies of temperamental traits are inconclusive and sometimes contradictory. A substantial amount of research has found support for the view that aspects of negative feelings, such as sadness and anger, indeed have approach as well as avoidance qualities, as opposed to feelings of positive affect alone which has been previously suggested (Carver, 2004; Carver & Scheier, 1998; Harmon-Jones & Sigelman, 2001; Higgins, 1996). Such research thus suggests a potential split of anger and sadness into two separate temperamental traits, with approach and avoidance qualities respectively (Carver, 2004; Carver & Harmon-Jones, 2009; Harmon-Jones, 2003), which would be a substantial modification to existing theories on temperament, such as Rothbart's theory and the r-RST. The relationship between aspects of affects and the approach and avoidance systems would therefore be both interesting and relevant to further investigate in research.

As previously described, risk-taking is a multi-dimensional concept. Risk-taking behavior varies across domains, and depends on both contextual and individual factors. In this thesis, we operationalize individual levels of risk-taking in the gambling domain as results on the BART-Y and the RDMT. To reach further understanding about risk-taking during middle childhood, future research could use additional risk-taking indexes such as questionnaires, or experimental tasks from other risk-taking domains. The combined use of biomarkers in experimental research can also provide interesting information about who will take a risk, why, and in what context. Such information might be helpful to all of us working with children, in trying to identify the children most in the danger-zone of maladaptive development.

Concluding remarks

This thesis concerns the influence of temperamental traits on risk-taking and decision-making in children. The unique contribution of this thesis is that we combined traits from three aspects of temperament to see how they coincide with risk-taking, under different contextual incentives. To our knowledge, this has never been done before. Effortful control is generally considered an important part of temperamental functioning, and has been repeatedly related to desired developmental outcomes. Results from study 2 and 3 provide information about how punishment and reward sensitivity systems interact in risk-taking, but also about the essential role of effortful control in avoiding risky decision-making. Such information is important for both intervention and prevention purposes. Finally we conclude that the TMCQ is a reliable questionnaire with the potential of becoming a useful, and much needed, instrument for assessing temperament during middle childhood. Although additional validation studies are needed before TMCQ validity can be fully established, our validity studies show good ability of assessing punishment and reward sensitivity as measured by the SPSRQ-C and thus in line with the most prominent theories of temperament. The conclusions from the current thesis are important since they can be helpful in establishing which children are at risk of developing maladaptive behavior, and hence strive to prevent it from happening.

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