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## CHAPTER

### *The relationship between adolescent risk-taking profiles and self-reported decision-making behaviour*

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## ABSTRACT

Immature levels of impulse control, combined with increases in sensation seeking, are thought to underlie the risk-taking behaviour often observed during adolescence. The current study examined how individual differences in the balance between sensation seeking and impulse control affected use of decision-making styles across various real-life situations. Participants were 337 typically developing mid-adolescents aged 13-15 years ( $M = 14.53$ ,  $SD = .92$ ) who completed self-report questionnaires and decision-making vignettes. Results showed that self-reported levels of cognitive control were more predictive of use of decision-making styles than the balance between sensation seeking and cognitive control. High levels of impulse control were associated with increased use of the more mature, rational decision-making style. Investigation of sex differences showed that girls made more use of rational, intuitive and dependent styles than boys.

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## INTRODUCTION

Adolescence is a period of both risks and opportunities. Originally viewed as a cultural construct (Richter, 2006), research has now empirically shown that it is a period during which an interplay of biological, psychological and environmental changes provide an opportunity for both adaptive and maladaptive developmental outcomes

(Calkins, 2010). An often-cited problem in adolescents' behaviour is their propensity for risky and reckless actions. For example, adolescents are more likely than adults and children to sustain unintentional injuries, be involved in traffic accidents, use drugs or engage in unsafe sexual behaviour (Reyna & Farley, 2006; Steinberg, 2004). These risk-taking behaviours raise questions about the level of decision-making abilities during adolescence, and have led to the suggestion that adolescents are generally poor decision-makers. Furthermore, the significant increase in risk-taking during adolescence, compared to both childhood and adulthood, suggests that the adolescent period is characterised by unique influences on decision-making behaviour.

Early studies of adolescent behaviour suggested that risk-taking during this period results from adolescents' beliefs of invulnerability or misjudging of risks compared to adults. According to Elkind's (1967) theory of adolescent egocentrism, adolescents often view themselves as unique and therefore immune to the consequences of their actions that they think might befall others. Subsequent studies have shown that, in fact, adolescents often perceive themselves as more vulnerable than adults do, and actually tend to overestimate risks (Millstein & Halpern-Felsher, 2002; Reyna & Farley, 2006). Adolescents who engage in high levels of risk behaviour also rate their chances of encountering adverse outcomes as high (Ellen, Boyer, Tschann, & Shafer, 1996). For example, Johnson, McCaul and Klein (2002) showed that adolescents, who smoked or had unprotected sex, estimated their risk of this type of behaviour leading to negative consequences as higher than adolescents who did not take risks. This suggests that adolescents do not engage in risk-taking behaviour due to suboptimal risk assessment: they are aware that their behaviour could have adverse consequences. If adolescents do not differ from adults in their risk-assessment, why then do adolescents take more risks than adults?

Recent findings in neurodevelopmental research provide an alternative explanation for the increase in risk-taking during adolescence. The brain continues to mature structurally and functionally during adolescence (see Giedd, 2008 for a review). Both cross-sectional and longitudinal studies have shown that these changes are especially pronounced in prefrontal and parietal regions of the brain (Giedd et al., 1999). The prefrontal cortex contains areas involved in a variety of cognitive abilities,

including impulse control. Structural changes in the prefrontal cortex are paralleled by gradual maturation of the cognitive control network, leading to increases in impulse control capacities from childhood through to adulthood (Davidson, Amso, Anderson, & Diamond, 2006). This continued development of impulse control abilities means that adolescents are yet to achieve adult levels of goal-directed behaviour. Immature levels of impulse control have been linked to impulsivity and poor decision-making (Geier, Terwilliger, Teslovich, Velanova, & Luna, 2010; Steinberg, 2008).

Yet if risk-taking were due to cognitive immaturity alone, children would be expected to show even higher rates of risk-taking than adolescents, as their cognitive abilities are even less developed than those of adolescents (Casey, Getz, & Galvan, 2008). This is not the case, with studies showing that development of risk-taking follows a curvi-linear trajectory, increasing during adolescence before decreasing from early adulthood (Steinberg, et al., 2008). This suggests that other processes alter the influence of the cognitive control system during development, leading to risk-taking behaviour. Specific attention has been paid to the modulatory effects of an imbalance in the developmental timing of the cognitive control network and another influential network in the adolescent brain, the social-emotional system. The latter network, which involves sub-cortical limbic regions, is involved in the processing of arousal, emotion and reward sensitivity (Steinberg, 2008). The increased sensitivity during adolescence of limbic areas makes adolescents more sensitive to rewards, such as the potential benefits of engaging in risky behaviour (Galvan, et al., 2006). This leads to the increases in sensation-seeking behaviour observed during adolescence (Steinberg et al., 2008). At the same time, the connectivity between the limbic and prefrontal areas is not yet sufficient for the cognitive control system to assert top-down control and suppress the reward- or incentive-driven behaviour of the limbic system (Somerville & Casey, 2010). As the cognitive control system develops and the integration of the networks improves, adolescents become increasingly able to override inappropriate choices and actions and thus self-regulate their behaviour in a goal-directed manner (Casey, et al., 2008; Nelson, Leibenluft, McClure, & Pine, 2005; Steinberg, 2008).

This unique developmental period, when sensation seeking increases and impulse

control has not yet fully matured, is a period of heightened probability of risk-taking behaviour. Though there are individual differences in the temporal development of these processes, this discrepancy is generally most pronounced between the ages of 13-15, the period known as mid-adolescence (Steinberg, et al., 2008). Even so, not all adolescents exhibit risk-taking behaviour during this period (Biglan & Cody, 2003), and those that do differ both quantitatively and qualitatively in their behaviours. The degree of disjunction between these processes may therefore be predictive of individual differences in the vulnerability towards risk-taking behaviour (Romer, 2010).

Previous research has indeed shown varying levels of risk-taking behaviours within groups of adolescents, both in laboratory tasks and 'real-life' measures (Rao, et al., 2011). A study by Biglan & Cody (2003) showed that in a sample of adolescents between the ages of 12 and 20 a minority of the individuals (18%) accounted for 88% of the criminal arrests. These individual differences in risk-taking tendencies may result in differing levels of decision-making competence among adolescents, for example through varying use of decision-making styles. Decision-making styles have been defined as the way in which an individual interprets and responds to decision-making tasks (Harren, 1979). These are characteristics of the decision-maker that have been found to influence decision-making behaviour and attitudes, for example career and health-related decisions (Crossley & Highhouse, 2005; Galotti, 2007). Scott and Bruce (1995) developed a taxonomy of five decision-making styles, namely: *rational* (characterised by a thorough search for and logical approach to consideration of alternatives), *intuitive* (characterised by a reliance on instincts and feelings), *dependent* (characterised by search for advice, assistance and direction from others), *avoidant* (characterised by attempts to avoid making decisions) and *spontaneous* (characterised by a desire to make decisions quickly). As adolescence is a period during which many important decisions are made, for example regarding education and future careers, immature decision-making abilities combined with increased risk-taking tendencies, could have life-long consequences. Therefore, in the present study we examine self-reported cognitive and social-emotional development in combination with the use of decision-making styles in a large group

of 318 mid-adolescents, aged 13-15 years. In line with previous studies (Steinberg, et al., 2008) the development of these systems was investigated through use of self-report questionnaires to measure impulse control (as a predictor of development of the cognitive control system) and sensation seeking (as predictor of development of the social-emotional system).

Consistent with the suggestion that impulse control and sensation seeking are distinct processes that together predict risk-taking tendencies, these processes were examined together rather than in isolation, through creation of risk-taking profiles based on the combination of these measures. As both sensation seeking and decision-making have been shown to differ between males and females (Ball, Farnill, & Wangeman, 1984; Dretsch & Tipples, 2011; Roth, Schumacher, & Brahler, 2005) we also examined the effect of sex in all our analyses. We hypothesise that the level of disjunction between the development of the cognitive control and social-emotional systems will typify the decision-making styles adolescents use. More specifically, adolescents in a low risk-taking group, characterised by high levels of impulse control and low levels of sensation seeking, are more likely to use rational decision-making styles than those in a high risk-taking group, meaning low levels of impulse control and high levels of sensation seeking. We expect that in the low risk-taking group, their cognitive control system will be better able to inhibit the impulses of the emotional system. Furthermore, we assume that high risk-taking adolescents will show a preference for spontaneous and intuitive decision-making styles, in line with their dominant emotional system. We do not expect differences in use of dependent or avoidant styles.

## **METHOD**

### *PARTICIPANTS*

Participants were recruited within a larger cross-sectional project examining the development of decision-making abilities during adolescence. The current sample incorporated all participants ( $N = 337$ ) in this study aged 13-15 years ( $M = 14.53$ ,  $SD = .92$ ). All participants in the analysed sample were typically developing, with no self-reported previous history of neurological, psychological or psychiatric disorders.

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## PROCEDURE

Participants were recruited through five schools in the Netherlands. Prior to testing, all parents were sent written information about the project. Both parents and participants were asked to sign and return the enclosed consent form if they wished to participate. Certain schools elected to modify this procedure and only asked for the signed form to be returned if parents did not wish for their child to participate. No parents objected to their child participating in the study.

Data collection took place during normal class time and was supervised by the classroom teacher and two trained psychologists. Participants were informed that participation was voluntary, that they could stop at any time and that all responses were confidential. Completion of all the questionnaires and tasks took approximately 45 minutes, with 5-10 minutes being spent on the questionnaires used in this study. All questionnaires were checked following completion. If answers were missing participants were subsequently asked to complete these items. The VU University Amsterdam institutional ethical review board approved all procedures.

## MEASURES

Participants were asked to report their age, sex and relevant medical history (e.g. diagnosed learning difficulties or behavioural problems). Reported medical problems were used to exclude those participants from the analyses who were not typically developing, due to neurological, psychological or psychiatric disorders ( $N=19$ ).

The *Barratt Impulsiveness Scale 11* (BIS; Stanford, Greve, Boudreaux, Mathias, & Brumbelow, 1996) was used to assess impulse control. This 30-item self-report scale measures behavioural and cognitive components of impulsivity. Items are rated on a 4-point scale (1= rarely/never, 4= always) with higher scores indicating greater impulsiveness and lower levels of impulse control.

The eight-item *Brief Sensation Seeking Scale* (BSSS; Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002) was used to measure sensation seeking behaviour. This frequently used questionnaire measures both socially acceptable and socially unacceptable types of sensation seeking. Participants respond on a five-point scale (1=strongly disagree, 5=strongly agree), with higher scores indicating increased

levels of sensation seeking.

A set of seven decision-making vignettes was created by the authors for use in this study to measure the use of decision-making styles by participants. These vignettes were based on the *General Decision-Making Style Inventory* (GDMS; Scott & Bruce, 1995). The GDMS consists of five sub-scales measuring five different decision-making styles: rational, intuitive, dependent, avoidant and spontaneous. The questionnaire was adapted to measure decision-making in situations the participants were likely to encounter in real-life, thereby increasing the ecological validity. Each vignette described a situation that required the participant to make a decision (e.g. buying a mobile phone, choosing a holiday). These vignettes were followed by five decisions, each related to one of five decision-making styles; rational, intuitive, dependent, avoidant and spontaneous. Participants were asked to indicate on a seven-point Likert-type scale for each of these five strategies how likely it was that they would use them in the situation described. This reflected the fact that the decision-making styles are not mutually exclusive and most individuals will use a combination of preferred styles when making a decision (Scott & Bruce, 1995). Answers across the seven vignettes were then summed per decision-making style to calculate a participant's total score for a particular style (see appendix 1 for an example of one of the vignettes used). The *General Decision-Making Style Inventory* (Scott & Bruce, 1995), was also administered to allow comparison of our task to the original questionnaire.

## ANALYSES

All analyses were performed using PASW Statistics 17.0 for Mac. The validity of the decision-making vignettes was examined by correlating scores per subscale on this task with scores per subscale on the GDMS. Risk-taking groups were created using each participant's total score on the BIS and BSSS. The mean scores for the entire sample on the BIS and BSSS were used to split the sample into two groups for each questionnaire. BIS scores below the mean were characterised as high impulse control and those above the mean as low impulse control. BSSS scores below the mean were characterised as low sensation seeking and those above the mean as high sensation

seeking. These groups were then combined to assign each participant to one of the four risk-taking groups, respectively (from low to high risk-taking):

1. High impulse control, low sensation seeking (Low)
2. High impulse control, high sensation seeking (Low-Medium)
3. Low impulse control, low sensation seeking (Medium-High)
4. Low impulse control, high sensation seeking (High)

The Low (group 1) and High risk-taking (group 4) groups are those with the biggest difference in the development of the systems examined and were therefore of primary interest in the data analyses. The decision to denote the high impulse control – high sensation seeking group (group 2) as a lower risk-taking group than the low impulse control – low sensation seeking group (group 3) was based on the assumption that in order to prevent risk-taking it is important to be able to override sensation seeking tendencies, even if these do not occur frequently (as is the case in group 3).

All effects are reported as significant at  $p < .05$ . Between-group differences between the risk-taking groups and sexes, with respect to use of the five decision-making styles, were examined using a 4 x 2 way multivariate analysis of variance (MANOVA). Interaction effects between the independent variables were included in the analysis. Significant main effects were further examined using post-hoc Bonferroni-adjusted pairwise comparisons where appropriate.

## **RESULTS**

### *VALIDITY OF THE DECISION-MAKING VIGNETTES*

Table 1 shows descriptive statistics and the correlations between the GDMS and decision-making vignette subscales. To examine the internal consistency of the decision-making vignette subscales, Cronbach's alpha was calculated for each of the five subscales.

The strongest relationships were found between the corresponding GDMS and vignette subscales. Additional correlations were found between the various subscales, which are to be expected, as the decision-making styles are not mutually

exclusive dimensions (Thunholm, 2004). Furthermore the intercorrelations followed a similar pattern to those found for the GDMS in previous studies (e.g. Loo, 2000; Scott & Bruce, 1995). Cronbach's alpha for the 35-item decision-making vignettes was .77, which is satisfactory, as were the measures of internal consistency for each of the five sub-scales (between .64 and .79).

**Table 1** - Descriptive statistics and correlations between GDMS and decision-making vignette (DMV) subscales.

DMV STYLES	M	SD	$\alpha$	CORRELATIONS WITH GDMS STYLES				
				RATIONAL	INTUITIVE	DEPENDENT	AVOIDANT	SPONTANEOUS
RATIONAL	5.42	.86	.79	<b>.48**</b>	.069	.24**	-.12**	-.22**
INTUITIVE	4.82	.79	.64	.04	<b>.40**</b>	.08	-.03	.20**
DEPENDENT	4.47	.95	.75	.19**	.10*	<b>.47**</b>	.12**	-.10*
AVOIDANT	2.61	.94	.75	-.24**	.02	-.01	<b>.44**</b>	.172**
SPONTANEOUS	2.92	.93	.73	-.20**	-.18**	.13**	.10*	<b>.41**</b>

Note: \*  $p < .05$ ; \*\*  $p < .01$ . Correlations between corresponding DMV and GDMS subscales are in boldface

### COMPARISON OF RISK-TAKING GROUPS

Participant characteristics for the four risk-taking groups are shown in Table 2. There were no significant differences between the groups with regards to age or sex. A four-way MANOVA was used to examine differences in impulse control and sensation seeking between the risk-taking groups. There was a significant main effect of risk-taking group on both impulse control and sensation seeking (Pillai's trace = 1.26,  $F(6, 658) = 187.0, p < .001$ ). Post hoc tests showed that the two lower sensation seeking groups reported significantly lower levels of sensation seeking behaviour than the two higher sensation seeking groups. A similar pattern was found for the impulse control groups, with again the two low impulse control groups reporting significantly more impulsive behaviour than the high impulse control groups.

### DIFFERENCES BETWEEN RISK-TAKING GROUPS IN DECISION-MAKING

Results of a four-way MANOVA showed a significant main effect of sex (Pillai's trace

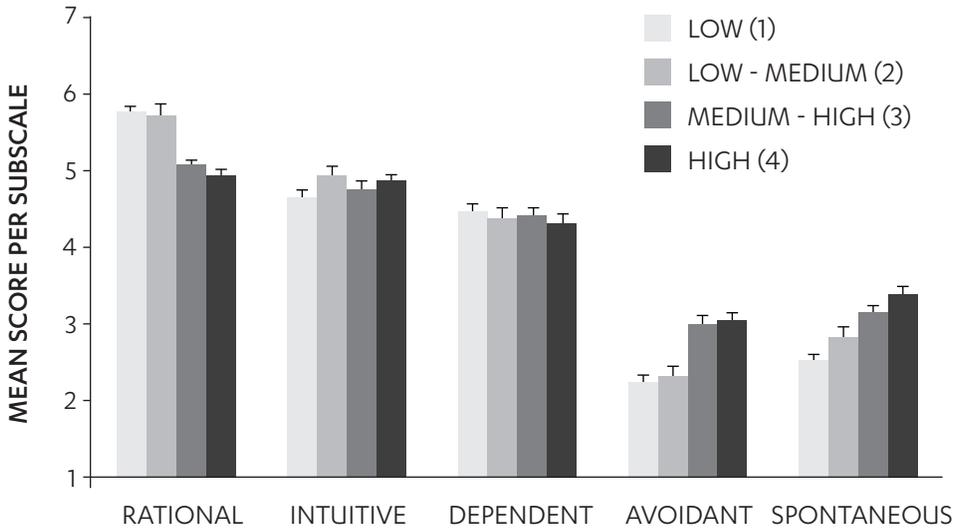
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= .077,  $F(5,306) = 5.14, p < .001$ ) and risk-taking group (Pillai's trace = .252,  $F(15,924) = 5.65$ ) on use of decision-making styles, as can be seen in Figures 1 and 2. The interaction between sex and risk-taking group was not significant. Girls reported increased use of the rational (Girls:  $M = 5.46, SD = .87$ , Boys:  $M = 5.36, SD = .87$ ), intuitive (Girls:  $M = 5.0, SD = .78$ , Boys:  $M = 4.66, SD = .77$ ) and dependent (Girls:  $M = 4.66, SD = .92$ , Boys:  $M = 4.24, SD = .95$ ) styles in comparison to boys. The risk-taking groups differed in their use of three of the styles: rational ( $F(3,310) = 16.15, p < .001$ ), avoidant ( $F(3,310) = 16.0, p < .001$ ) and spontaneous ( $F(3,310) = 15.31, p < .001$ ). Post-hoc tests showed that consistent with our hypothesis, the low risk-taking groups (Low risk group:  $M=5.74, SD=.74$  and Low-medium risk group:  $M=5.67, SD=.66$ ) made significantly more use of the rational style than the high risk-taking groups (Medium-high risk group:  $M = 5.15, SD = .93$  and High risk group:  $M = 5.09, SD = .86$ ) and the high risk-taking groups (Medium-high risk group:  $M = 3.11, SD = .87$  and High risk group:  $M = 3.29, SD = .95$ ) made significantly more use of the spontaneous style than the low risk-taking groups (Low risk group:  $M = 2.50, SD = .81$  and Low-medium risk group:  $M = 2.79, SD = .83$ ). Contrary to our hypothesis, we found no differences between the groups in use of the intuitive decision-making style.

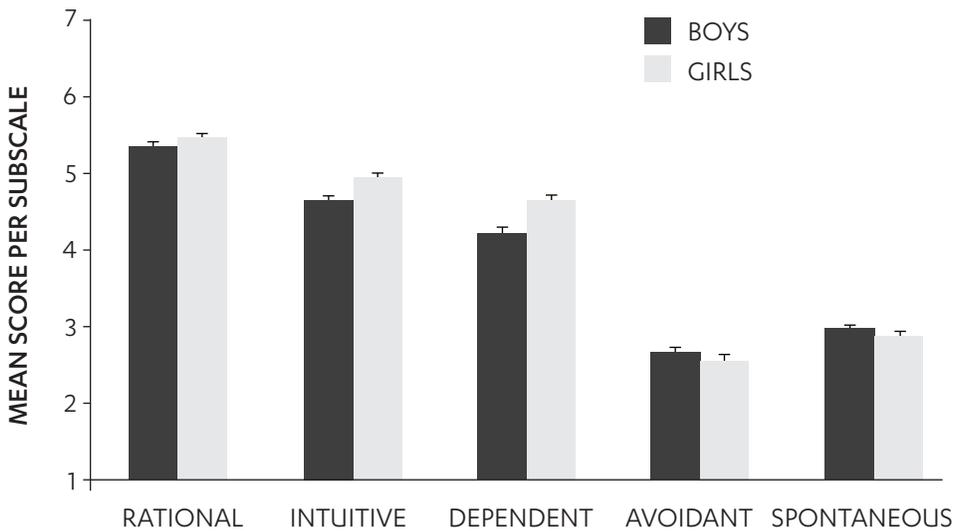
**Table 2** - Descriptive statistics of risk-taking groups

	N	AGE M (SD)	MALE:FEMALE RATIO	MEAN BIS SCORE	MEAN BSSS SCORE
LOW RISK	96	14.51 (.97)	48:48	3.22 (.17)	2.26 (.48)
LOW-MEDIUM RISK	67	14.46 (.87)	30:37	3.20 (.15)	3.43 (.38)
MEDIUM-HIGH RISK	48	14.37 (.92)	21:27	2.83 (.15)	2.44 (.33)
HIGH RISK	107	14.78 (.90)	46:61	2.74 (.20)	3.54 (.38)
TOTAL	318	14.53 (.92)	145:173	3.00 (.17)	2.92 (.39)

However, we did find that the high risk-taking groups (Medium-high risk group:  $M = 3.02, SD = .81$  and High risk group:  $M = 2.93, SD = .96$ ) reported increased use of the avoidant style compared to low risk-taking groups (Low risk group:  $M = 2.25, SD$



**Figure 1** - Mean scores per subscale of the decision-making vignettes for each of the risk-taking groups. Use of rational, avoidant and spontaneous styles differed significantly between groups. Error bars represent standard errors.



**Figure 2** - Mean scores per subscale of the decision-making vignettes for boys and girls. Girls reported increased use of rational, intuitive and dependent styles in compared to boys. Error bars represent standard errors.

= .87 and Low-medium risk group:  $M = 2.32$ ,  $SD = .81$ ). There were no differences within the high and low groups in use of the decision-making styles.

## DISCUSSION

In this study we examined the influence of the maturational gap between the impulse control and emotional systems on the use of decision-making styles. This gap is thought to be an important cause of risk-taking behaviour during adolescence (Somerville & Casey, 2010; Steinberg, 2008). In line with our hypotheses, the results show that adolescents in the four risk-taking groups differentially employed decision-making styles. Comparison of the groups showed that low levels of reported sensation seeking in combination with high levels of impulse control (Low risk-taking groups) were associated with increased use of the rational decision-making style. It has been suggested that the rational style is the optimal style to use when making decisions (Galotti, 2007; Mau & Jepsen, 1992) and previous research has shown an increase in the use of this style with age during adolescence (Baiocco, Laghi, & D'Alessio, 2009). High levels of sensation seeking and low levels of impulse control (High risk-taking group) were related to increased use of the spontaneous style, as we expected, as well as use of the avoidant style. Use of these styles has previously been found to decrease with age (Baiocco, et al., 2009; Loo, 2000). Increased use of the spontaneous style has previously been related to decreases in levels of academic achievement (Loo, 2000).

If we compare our results to previous age-related findings, we see that the differences between our low risk-taking and high risk-taking groups are the same as those between previously compared samples of young versus older adolescents (Baiocco, et al. 2009). This suggests that the disjunction may indeed be part of a developmental trajectory, characterised by low impulse control and high levels of sensation seeking at the low end and high impulse control combined with lower levels of sensation seeking at the other end. Furthermore it shows that those at the far end of the trajectory are able to make more rational, well-informed decisions.

Interestingly, analysis of the two non-disjunction groups (Low-Medium risk-taking group and Medium-High risk-taking group) showed that the Low-Medium group reported similar decision-making behaviour to the Low risk-taking group and

the Medium-High group was similar to the High risk-group. Further examination of the four groups showed that differences were in fact only found between those groups that differed in their reported levels of impulse control. This suggests that the use of decision-making styles is influenced only by an individual's level of impulse control and not by sensation seeking or the relative disjunction between the development of the cognitive and emotional systems. This is in contrast to findings by Baiocco et al. (2009), who reported significant correlations in a large sample of Italian adolescents between the rational, intuitive, dependent and spontaneous styles and sub-scales of Zuckerman's Sensation Seeking Scale (SSS). This may be due to our use of an adapted version of the GDMS questionnaire, which required application of decision-making styles to real-life situations. However, this important role for impulse control was also found by Franken, van Strien, Nijs & Muris (2008), who showed that individuals with high levels of self-reported impulsivity showed an impaired ability to make appropriate decisions on behavioural decision-making tasks. It may be the case that lack of impulse control inhibits incorporation of knowledge of risks into the decision to take risks. This would explain why adolescents are able to judge risks accurately, but these judgments do not influence their behaviour. This hypothesis needs to be examined further by combining a 'real-life' measure of risk-taking with information on cognitive and emotional development across multiple age-groups. As far as we know, no studies have been done assessing the relative contribution of these systems to actual risk-taking behaviour.

Our study also found sex differences in decision-making styles. In contrast to previous studies (Baiocco, et al., 2009; Spicer & Sadler-Smith, 2005), which found no differences, adolescent girls in our sample made more use of rational, intuitive and dependent styles than the boys. These differences may again be attributable to our use of decision-making vignettes instead of the GDMS questionnaire. The original questionnaire requires the participant to answer abstract questions about the way in which they make decisions (e.g. "When making decisions I rely upon my instincts"). Our adapted version implemented the decision-making strategies in real-life situations. Previous research has shown that adolescent girls have better perspective-taking abilities than boys when confronted with hypothetical situations

(Keulers, Evers, Stiers, & Jolles, 2010). Therefore, girls may have benefitted more from framing their answers in the hypothetical situations we presented than boys, thereby leading to sex differences not found on the original questionnaire.

In summary, we have demonstrated that use of decision-making styles during adolescence is influenced by sex as well as by individual differences in impulse control. Contrary to our hypothesis, the influence of impulse control seemed greater than that of the maturational gap between the cognitive and social-emotional systems, which is thought to lead to risk-taking. This distinction is important, as adequate identification of the characteristics of risk-takers will help elucidate the areas most likely to benefit from future interventions.

Finally, we feel it is important to note that not all adolescent risk-taking is problematic. In fact the exploration, creativity, learning and discovery that is part of low level risk-taking can actually be very beneficial to development, enabling the adolescent to distance themselves from their family and adopt the independent role needed to transition into adulthood (Dahl, 2011; Romer, 2010). Positive risk-taking helps adolescents to learn new skills and to engage in activities that challenge them and offer enriching new experiences. The challenge for parents, teachers and such is therefore to guide these adolescent drives in such a way that they lead to positive outcomes.

## REFERENCES

- Baiocco, R., Laghi, F., & D'Alessio, M. (2009). Decision-making style among adolescents: Relationship with sensation seeking and locus of control. *Journal of Adolescence*, 32, 963-976.
- Ball, I. L., Farnill, D., & Wangeman, J. F. (1984). Sex and Age-Differences in Sensation Seeking - Some National Comparisons. *British Journal of Psychology*, 75, 257-265.
- Biglan, A., & Cody, C. (2003). Preventing multiple problem behaviours in adolescence. In D. Romer (Ed.), *Reducing adolescent risk: Toward an integrated approach* (pp. 125-131). Thousand Oaks: Sage Publications.
- Calkins, S. D. (2010). Psychobiological models of adolescent risk: Implications for prevention and intervention. *Developmental Psychobiology*, 52, 213-215.
- Casey, B. J., Getz, S., & Galvan, A. (2008). The adolescent brain. *Developmental Review*, 28, 62-77.
- Crossley, C. D., & Highhouse, S. (2005). Relation of job search and choice process with subsequent satisfaction. *Journal of Economic Psychology*, 26, 255-268.

- Elkind, D. (1967). Egocentrism in adolescence. *Child Development*, 38, 1025-1034.
- Dahl, R. (2011). Understanding the Risky Business of Adolescence. *Neuron*, 69, 837-839.
- Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, 44, 2037-2078.
- Dretsch, M. N., & Tipples, J. (2011). Sex differences moderate decision making behaviour in high impulsive sensation seekers. *Cognition & Emotion*, 25, 149-155.
- Ellen, J. M., Boyer, C. B., Tschann, J. M., & Shafer, M. A. (1996). Adolescents' perceived risk for STDs and HIV infection. *Journal of Adolescent Health*, 18, 177-181.
- Franken, I. H. A., van Strien, J. W., Nijs, I., & Muris, P. (2008). Impulsivity is associated with behavioral decision-making deficits. *Psychiatry Research*, 158, 155-163.
- Galotti, K. M. (2007). Decision structuring in important real-life choices. *Psychological Science*, 18, 320-325.
- Galvan, A., Hare, T.A., Parra, C.E., Penn, J., Voss, H., Glover, G. & Casey, B.J. (2006). Earlier development of the accumbens relative to orbitofrontal cortex might underlie risk-taking behavior in adolescents. *Journal of Neuroscience*, 26, 6885-6892.
- Geier, C. F., Terwilliger, R., Teslovich, T., Velanova, K., & Luna, B. (2010). Immaturities in Reward Processing and Its Influence on Inhibitory Control in Adolescence. *Cerebral Cortex*, 20, 1613-1629.
- Giedd, J.N. (2008). The teen brain: insights from neuroimaging. *Journal of Adolescent Health*, 42, 335-343.
- Giedd, J. N., Blumenthal, J., Jeffries, N. O., Castellanos, F. X., Liu, H., Zijdenbos, A., Paus, T., Evans, A. C. & Rapoport, J. L. (1999). Brain development during childhood and adolescence: a longitudinal MRI study. *Nature Neuroscience*, 2, 861-863.
- Harren, V. A. (1979). Model of Career Decision-Making for College-Students. *Journal of Vocational Behavior*, 14, 119-133.
- Hoyle, R. H., Stephenson, M. T., Palmgreen, P., Lorch, E. P., & Donohew, R. L. (2002). Reliability and validity of a brief measure of sensation seeking. *Personality and Individual Differences*, 32, 401-414.
- Johnson, R. J., McCaul, K. D., & Klein, W. M. P. (2002). Risk involvement and risk perception among adolescents and young adults. *Journal of Behavioral Medicine*, 25, 67-82.
- Keulers, E. H. H., Evers, E. A. T., Stiers, P., & Jolles, J. (2010). Age, Sex, and Pubertal Phase Influence Mentalizing About Emotions and Actions in Adolescents. *Developmental Neuropsychology*, 35, 555-569.
- Loo, R. (2000). A psychometric evaluation of the General Decision-Making Style Inventory. *Personality and Individual Differences*, 29, 895-905.
- Mau, W. C., & Jepsen, D. A. (1992). Effects of Computer-Assisted-Instruction in Using Formal Decision-Making Strategies to Choose a College Major. *Journal of Counseling Psychology*, 39, 185-192.
- Millstein, S.G. & Halpern-Felsher, B.L. (2002). Judgments about risk and perceived invulnerability in adolescents and young adults. *Journal of Adolescent Research*, 12, 399-422.
- Nelson, E. E., Leibenluft, E., McClure, E. B., & Pine, D. S. (2005). The social re-orientation of

- adolescence: a neuroscience perspective on the process and its relation to psychopathology. *Psychological Medicine*, 35, 163-174.
- Rao, U., Sidhartha, T., Harker, K. R., Bidesi, A. S., Chen, L. A., & Ernst, M. (2011). Relationship Between Adolescent Risk Preferences on a Laboratory Task and Behavioral Measures of Risk-Taking. *Journal of Adolescent Health*, 48, 151-158.
- Reyna, V. F., & Farley, F. (2006). Risk and rationality in adolescent decision making - Implications for theory, practice, and public policy. *Psychological Science in the Public Interest*, 7, 1-44.
- Richter, L. M. (2006). Studying adolescence. *Science*, 312(5782), 1902-1905.
- Romer, D. (2010). Adolescent risk taking, impulsivity, and brain development: Implications for prevention. *Developmental Psychobiology*, 52, 263-276.
- Roth, M., Schumacher, J., & Braehler, E. (2005). Sensation seeking in the community: Sex, age and sociodemographic comparisons on a representative German population sample. *Personality and Individual Differences*, 39, 1261-1271.
- Scott, S. G., & Bruce, R. A. (1995). Decision-making style: the development and assessment of a new measure. *Educational and Psychological Measurement*, 55, 818-831.
- Somerville, L. H., & Casey, B. J. (2010). Developmental neurobiology of cognitive control and motivational systems. *Current Opinion in Neurobiology*, 20, 236-241.
- Spicer, D. P., & Sadler-Smith, E. (2005). An examination of the General Decision-making Style questionnaire in two UK samples. *Journal of Managerial Psychology*, 20, 137-149.
- Stanford, M. S., Greve, K. W., Boudreaux, J. K., Mathias, C. W., & Brumbelow, J. L. (1996). Impulsiveness and risk-taking behavior: comparison of high-school and college students using the Barratt Impulsiveness Scale. *Personality and Individual Differences*, 21, 1073-1075.
- Steinberg, L. (2004). Risk taking in adolescence: what changes, and why? *Annals of the New York Academy of Sciences*, 1021, 51-58.
- Steinberg, L. (2008). A social neuroscience perspective on adolescent risk-taking. *Developmental Review*, 28, 78-106.
- Steinberg, L., Albert, D., Cauffman, E., Banich, M., Graham, S., & Woolard, J. (2008). Age differences in sensation seeking and impulsivity as indexed by behavior and self-report: Evidence for a dual systems model. *Developmental Psychology*, 44, 1764-1778.
- Thunholm, P. (2004). Decision-making style: habit, style or both? *Personality and Individual Differences*, 36, 931-944.

## APPENDIX 1. EXAMPLE OF DECISION-MAKING VIGNETTE

Imagine you have nearly finished secondary school and want to go to university. To be able to do so you need to choose a course to apply for. You have attended open days at a number of universities, read brochures and researched courses on the internet. Now it's time to submit your application and decide between the courses you've been considering.

Please indicate for each of the following questions how likely you are to use this strategy when making your decision:

	EXTREMELY UNLIKELY		NOT LIKELY/ NOT UNLIKELY			EXTREMELY LIKELY	
	1	2	3	4	5	6	7
1. I would carefully consider the differences between the courses and make sure I had all the information I needed before making a decision.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. I would choose the course that seems most interesting, without weighing the pros and cons	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. I would ask other people which course they think I should apply for	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. I would avoid choosing a course until the deadline	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. I would quickly choose a course without really thinking about it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>