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Cognitive-control as a Moderator of Temperamental Motivations Toward Adolescent Risk-Taking Behavior

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Abstract

Few studies have directly examined whether cognitive-control can moderate the influence of temperamental positive and negative-affective traits on adolescent risk-taking. Using a combined multi-method, latent variable approach to the assessment of adolescent risk-taking and cognitive-control, this study examined whether cognitive-control moderates the influence of temperamental Surgency and Frustration on risk-taking in a sample of 177 adolescents (M_{age}=16.12 years, SD=0.69). As predicted, there was a significant interaction between *Cognitive-control* and *Frustration*, but not between *Cognitive-control* and *Surgency*, in predicting *Risk-taking*. These findings have important implications and suggest that the determinants of adolescent risk-taking depend on the valence of the affective motivation for risk-taking behavior.

Cognitive-control as a Moderator of Temperamental Motivations towards Adolescent Risk-taking Behavior

Epidemiological studies provide robust evidence that adolescence is a period of increased participation in risk-taking behaviors associated with significant negative outcomes (CDC, 2010). Many current models of adolescent risk-taking, based in developmental neuroscience (e.g., Casey, Getz, & Galvan, 2008; Ernst, Pine, & Hardin, 2006; Reyna & Rivers, 2008; Steinberg, 2005, 2008), suggest that differences in the temporal neuromaturation of approach/novelty-seeking systems (mature earlier in adolescence), relative to later maturing neurocircuitry underlying *cognitive-control* — defined as the ability to coordinate thoughts and actions to maintain purposeful goal directed behavior (Braver, 2012) — may explain why adolescents are predisposed to engaging in risk-taking behaviors, particularly when experiencing affective arousal.

Despite the evidence presented in neurodevelopmental models, few studies have directly tested the premise that cognitive-control can moderate the influence of affective motivations towards risk-taking during adolescence. Moreover, neurodevelopmental studies have focused primarily on explaining why adolescents engage in more risk-taking behavior relative to adults. Moving beyond this, it can be reasonably inferred that individual differences in these neurodevelopmental circuits that are linked to observable phenotypic traits such as *temperament* may prove important for identifying particular adolescents who may be susceptible to these behaviors. Temperament represents a uniquely important construct in adolescent risk-taking research given it is putatively mediated by the affective and cognitive-control brain circuits implicated in neurodevelopmental models of adolescent risk-taking (see Whittle et al., 2008). Moreover, temperament can be easily assessed in youth participants since the construct, and its measurement tools, were designed specifically for child and adolescent populations.

Despite the utility of temperament in adolescent risk-taking research, few studies have examined this construct in adolescent samples. Nevertheless, positive temperamental traits have been linked to risk-taking behaviors including "heavy dependent" smoking status (Rezvanfard, Ekhtiari, Mokri, Djavid, & Kaviani, 2010) and increased self-reported alcohol consumption

(Skeel, Pilarski, Pytlak, & Neudecker, 2008). By contrast, studies examining the role of temperamental negative-affectivity (i.e., the tendency to experience negative-affects such as sadness, fear or frustration) in adolescent risk-taking have found inconsistent results. For example, negative-affectivity was shown to be negatively correlated with self-reported daily alcohol consumption (Skeel et al., 2008), positively correlated with externalizing symptoms (Honomichl & Donnellan, 2011; Oldehinkel, Hartman, Ferdinand, Verhulst, & Ormel, 2007), and not correlated with adolescent smoking (Rezvanfard et al., 2010), or general risk-taking (Honomichl & Donnellan, 2011). It is possible that this inconsistency may be a consequence of heterogeneity in the measurement of the negative-affectivity construct with evidence supporting delineation between negative-affective responses characterized by anxiety/fear, and those characterized by frustration/irritability (Caspi, et al., 2005). Given that adolescence represents a developmental period characterized by numerous opportunities to become frustrated (Berdan, et al., 2008), it is possible that a frustration based measure of negative-affectivity may be more consistently related to risk-taking during this period. Indeed the construct of Negative Urgency (Whiteside & Lynam, 2001), which characterizes an individual's tendency to act impulsively when experiencing frustration-based negative emotions, provides support for this delineation since it has been shown be associated with adolescent risk behaviours such as sex risk-taking (Deckman & DeWall, 2011) and substance use (Stautz & Cooper, 2014).

Measures of temperamental cognitive-control (i.e., effortful control) have been examined only sporadically in the context of adolescent risk-taking behavior. Whilst low temperamental cognitive-control was associated with increased cannabis use (Creemers et al., 2010) and externalizing behaviors (Oldehinkel et al., 2007) during adolescence, others have found this variable does not independently predict frequency, age of first use, or quantity, of alcohol use (Willem, Bijttebier, & Claes, 2010). Of relevance, recent evidence has demonstrated that temperamental cognitive-control shows strong conceptual and statistical overlap with other measures of executive functioning skills, and it has been suggested that an integrative multi-method approach that incorporates a range of measures will provide the most accurate representation of the cognitive-control construct (Bridgett, Oddi, Laake, Murdock, & Bachmann, 2013; Zhou, Chen, & Main, 2012). Consequently, classical tasks of cognitive-control functioning such as the Stroop, Multisource Interference Task, Go-NoGo, stop-signal, or anti-saccade tasks (assessing reaction times and response inhibition errors) may be useful for supplementing temperamental cognitive-control in the multi-method measurement of this construct. Furthermore, given that the putative neural underpinning of cognitive-control converges with that of high intellectual functioning (Jung & Haier, 2007; Neubauer & Fink, 2009), understanding how cognitive-control is related to adolescent risk-taking behavior must also account for an adolescent's intelligence.

There is a paucity of studies explicitly testing whether cognitive-control and temperamental affective traits interact to predict adolescent risk-taking. Of the few, a study of 143 male adolescents (M_{age}=18.62 years) found that temperamental negative-affectivity predicted substance use problems but only in adolescents who concurrently scored low on a trait measure of cognitive-control (Shoal & Giancola, 2003). Similarly, the influence of temperamental negative-affectivity on later externalizing problems was found to be attenuated by high temperamental effortful control (Oldehinkel et al., 2007). Whilst these studies provide preliminary evidence for a moderation effect, Shoal and Giancola's focus on substance use restricts the inferences that can be generalized to risk-taking participation more broadly. By contrast, Oldehinkel et al. utilized a derived measure of externalizing that was too broad because it included many non-risk-taking behaviors (e.g., aggression). Moreover, given the young age of the Oldehinkel et al. sample (M_{age}11 and 13years), it is unclear whether the identified interaction between effortful control and negative-affectivity can be generalized to older adolescents who are engaged in a greater prevalence of harmful risk-taking behavior. Notably, no study has examined the interaction between cognitive-control and temperamental positive-affectivity in adolescent risk-taking.

This study aimed to determine whether a multi-method measure of cognitive-control moderates the influence of temperamental positive-affectivity, and a frustration based measure of negative-affectivity, on general adolescent risk-taking. It was hypothesized that high temperamental frustration, high temperamental positive-affectivity and low cognitive-control would significantly predict adolescent risk-taking behavior. Additionally, it was hypothesized that after controlling for intelligence, the direct effects of temperamental frustration and positive-affectivity on risk-taking would be moderated by cognitive-control, such that higher levels of cognitive-control would reduce the association between these affective traits and adolescent risk-taking behavior.

Method

Participants and Data Collection Procedure

All participants were recruited from the *Orygen Adolescent Development Study* (ADS), a large longitudinal study of adolescent development conducted at Orygen Youth Health Research Center (The University of Melbourne), Victoria, Australia. Comprehensive descriptions of the methodology employed in the initial recruitment of participants into the ADS have been presented in other publications (Whittle et al., 2008; Yap et al., 2011). This present study comprised of cross-sectional data obtained from the 177 adolescents ($M_{age=}$16.12 years, SD=0.69; 83 males) who participated in Wave 3 (2007-2008) of assessments. There was no significant differences between the 177 participants who completed Wave 3, and those who did not (n=238), on age (p=.30), gender composition (p=.69), and Wave 1 measures of Temperamental Surgency (p=.65), Frustration (p=.72), and Effortful Control (p=.55). In the Wave 3 sample, there was no significant difference between the age of male and females (p=.17) and the majority (97.7%) of the sample ranged in age from 15 to 17 years. Of the 177 participants, 85.9% identified as "White-Caucasian", 3.4% identified as "White-Caucasian" + other race, 4% identified as "Asian", 4% identified as "Other" and 2.8% did not indicate their identified race. Socioeconomic status (SES) was calculated using the Australian National University-4 Status Scale (ANU4-SES; Jones & McMillan, 2001). The sample was generally of high SES with more than 62% of the sample having an ANU4-SES score greater than 70 ($M_{SES=}$63.46, SD=20.73).

Measures and Data Analysis

Details about the measures used in the current study, and which items were used in each latent variable are provided in Table 1 and further details of the measures (e.g., psychometrics) are presented in Table S1. The development of the *Cognitive-control, Risk-taking, Surgency, Frustration*, and *Intelligence* latent variables are presented in subsequent sections.

The primary outcome analyses were performed in Mplus (v7.2). Missing data was accounted for using a full information maximum likelihood method. We used Structural Equation Modeling (SEM) to examine the hypotheses of interest in which all variables of interest were estimated as latent variables. The names of latent variables are presented in italicized font. SEM models used to test the hypotheses were estimated using the robust MLR estimator

(Muthén & Muthén, 1998-2012; Myung, 2003). Interaction terms were created using the Mplus XWITH function, however, common measures of statistical fit (e.g., χ2-test, WRMR, RMSEA, and CFI fit indices) are not available with models that use latent variable interactions due to adjustments made during estimation (Muthén & Muthén, 1998-2012). As such measures of relative fit (e.g., Bayesian Information Criteria) were used to test competing models. Nested models were compared with loglikelihood ratio difference tests using an appropriate correction for the MLR estimator (Satorra & Bentler, 2010). We increased the efficiency of estimation by rescaling variables so that the variance for each variable was between 1 and 10 (Muthén, 2010, March 26) and utilized a Monte Carlo integration method to reduce computation time (Muthén & Muthén, 1998-2012).

Developing the Latent Variables

Risk-taking. As presented in Table 2, we used ten items from the Youth Risk Behavior Surveillance System (YRBS) that were selected based on their coverage of a broad range of prototypical risk-taking behaviors. Confirmatory factor analysis (CFA) revealed a unidimensional factor structure with all items loading significantly on a single *Risk-taking* factor (χ^2[19]= 26.91, p=.11; N=174; CFI=.986, RMSEA=.049). This model (with the exception of the gambling item which was unavailable) was replicated using CFA in a sample of 4135 16-year-old adolescents from the US based 2009 Youth Risk Behavior Survey (available from www.cdc.gov/HealthyYouth/yrbs/index.htm). The model provided good fit (χ^2[25]=258.86, p<.001; CFI=.972, RMSEA=.048) and as presented in Table 2, factor loadings for the items were consistent with the current sample in strength and direction supporting the external validity of this model.

Cognitive-control. A multi-method approach was used to estimate the latent cognitive-control variable. Initially we specified three lower latent factors of *Effortful-Control*, *Errors* and *Reaction-Times* (indicators are presented in Table 1). Finally, we estimated a second-order factor model in which *Cognitive-control* was the higher-order factor for the three lower order latent dimensions. This base model had a significant χ^2 but good fit to the data (χ^2[20]=32.64, p=.037; n=177; CFI=.919, RMSEA=.060). Additionally, all variables were significant indicators of their respective latent variable (i.e. *Effortful-Control*, *Errors* and *Reaction-Times*) and these latent variables were in turn significant indicators of the higher order *Cognitive-control* latent variable.

A model that included the MSIT Congruent errors did not improve model fit (96.9% had less than 1 error) and was removed from further analysis. This multi-method model, which had good statistical fit, was therefore consistent with previous studies demonstrating a multi-method approach to be beneficial for representing the cognitive-control construct (Bridgett et al., 2013; Zhou et al., 2012). To reduce parameters estimated in later analyses, factor scores were retained for *Reaction-Times*, *Errors* and *Effortful-Control* and used as observed indicators of *Cognitive-control*.

Surgency, Frustration, and Intelligence. Factor scores for the High Intensity Pleasure, (low) Shyness and (low) Fear subscales were used as indicators of a latent *Surgency* variable (Table 1). Further analysis found that a model in which the *Surgency* indicators were tau equivalent (but not parallel) improved model fit and therefore this was retained for analysis. The *Frustration* factor was indicated by the single observed Frustration factor score, with the residual variance of this indicator set to (1-scale reliability)*(the raw data sample variance) in order to account for measurement error (Brown, 2006). Practically, this involved setting the residual variance of the Frustration variable to .20 (based on internal consistency reliability of α=.72, Muris and Meesters (2009)) . This single indicator approach was also utilized for the measure of intelligence (denoted as *FSIQ*) with the residual variance of the estimated full scale IQ observed variable set to .13 (based on scale reliability of r_{ss}=.92, Sattler and Dumont (2004)).

Results

For all analyses, Little's test for MCAR supported the assumption that missing data were missing completely at random (p=1.00). A correlation matrix between all observed variables is provided in Table S2. An initial measurement model (without interaction terms) found that *Risk-taking* had significant (p<.001) and moderately strong positive correlations with *Surgency* (r=.49), and *Frustration* (r=.39), and was negatively correlated with *Cognitive-control* (r=-.43) and *FSIQ* (r=-.25). A strong negative correlation was found between *Frustration* and *Cognitive-control* (r=-.71; p<.05), and *Cognitive-control* was positively related to *FSIQ* (r=.39, p<.001). Notably, sex and SES were not correlated with any variables in the model and were thus removed from further analysis to reduce model complexity.

To test the primary hypotheses, *Risk-taking* was regressed onto *Cognitive-control*, *Surgency*, *Frustration*, and the two interaction terms. We trimmed non-significant relationships based on the results of χ^2 difference testing and the most parsimonious final model is presented in Figure 1 (NB: indicators are omitted from Figure 1, however, the full path-diagram is provided as Figure S1). *Cognitive-control*, *Surgency* and *Frustration* had direct effects on *Risk-taking* whilst the effect of *FSIQ* on *Risk-taking* consisted entirely of an indirect effect through *Cognitive-control*. The *Cognitive-control* x *Surgency* interaction did not predict *Risk-taking*. By contrast, the *Cognitive-control* x *Frustration* interaction term was significant. This is presented diagrammatically in Figure 2, based on the protocol outlined in Muthén (2012). These data indicate that the relationship between *Frustration* and *Risk-taking* was attenuated in participants with better *Cognitive-control* (i.e., +1*SD*) and magnified in those with poorer *Cognitive-control* functioning (i.e., -1*SD*). Finally, the interpretation of all relationships remained unchanged when controlling for age (in months), which was a significant negative predictor of *Risk-taking* (b=-0.30, p<.001).

Discussion

Consistent with predictions, results found that high surgency, high frustration, and low cognitive-control had significant direct effects on risk-taking behavior. As hypothesized, the results also provided evidence that cognitive-control moderated the relationship between frustration and risk-taking but not between surgency and risk-taking. With respect to covariates, analyses found that the influence of FSIQ on adolescent risk-taking was fully mediated by cognitive-control. Additionally, these results remained unchanged when controlling for age. Finally, sex and socioeconomic status were not related to risk-taking behavior, nor any other variables examined in the current study.

The study found that a poorer level of the multi-method latent *Cognitive-control* variable was a significant predictor of high *Risk-taking* (see Figure 1), a finding that is consistent with studies demonstrating that differential traits converging with the construct of cognitive-control (e.g., effortful control, response inhibition errors and reaction times) are related to adolescent risk-taking behavior. The current results extend on these findings by demonstrating this relationship when utilizing a robust assessment of cognitive-control that incorporated a multimodal method (i.e., errors and reaction-times on two separate response inhibition paradigms, and a trait based assessment of temperamental effortful-control) of assessment of this construct.

As hypothesized, high *Surgency* had a significant direct effect on high *Risk-taking* but there was no support for an interaction between *Surgency* and *Cognitive-control* in predicting *Risk-taking* (Figure 1). A possible explanation for this result may be found in the specific mechanisms by which Surgency, and other positive-affect-related variables, are related to risk-taking behavior. Positive-affective traits manifest as an increased engagement with the environment to seek out reward and positive-affective experiences (Rothbart, Ahadi, & Evans, 2000; Whittle, Allen, Lubman, & Yücel, 2006) suggesting that positive-affective traits may be linked to risk-taking by increasing an individual's exposure to risk-taking contexts. For example, using research on sensation seeking, which is a positive-affective trait that shares strong conceptual and statistical overlap with temperamental positive-affectivity (see Zuckerman, 1994; 2007), Boyer and Byrnes (2009) found that the relationship between sensation seeking and risk-taking participation was mediated by the number of opportunities available to engage in risk-taking behaviors. Moreover, Boyer and Byrnes found that when controlling for opportunities to engage in risk-taking, the relationship between sensation seeking and risk-taking was attenuated. In other words, positive-affective motivations such as sensation seeking and temperamental positive-affectivity may drive individuals to seek out new and novel experiences in their environment, and in doing so, places them at increased exposure to opportunities to engage in risk-taking behaviors. Others have supported this premise with evidence that sensation seeking can predict both occasional *and* frequent risk-taking, which supports the idea that trait positive-affective motivations exerts a generalized predisposition (i.e., both occasional and frequent) to any level of risk-taking behavior (Desrichard & Denarié, 2005). As such, whilst speculative and needing replication using the Surgency construct specifically, cognitive-control functioning may not have a regulatory influence on temperamental positive-affective motivations because these traits represent a generalized predisposition towards exciting and novel environments (a response that does not require regulation), rather than a propensity toward risk-taking behaviors specifically.

As hypothesized, this study demonstrated that high *Frustration* had a significant direct effect on high *Risk-taking.* Past studies were inconsistent in identifying robust relationships between negative-affectivity dispositional traits and risk-taking in adolescent samples and these results therefore provide evidence to suggest that future studies will benefit from delineating between heterogeneous aspects of the negative-affective spectrum and in particular, may focus on frustration. Perhaps more interesting was the significant *Frustration x Cognitive-control* interaction. As hypothesized, this result provides evidence to suggest that the effect of *Frustration* in predicting *Risk-taking* is attenuated by better cognitive control functioning, and amplified when an individual has poor cognitive-control. From a cognitive perspective, the ability to engage in deliberative regulation of frustration based emotions may be particularly important for inhibiting reactionary risk-taking responses. In particular, those who have strong cognitive-control may be more able to use effective coping strategies (e.g., problem focused coping) for the regulation of emotional environmental contexts and less likely to manage frustration by using drugs, violence, or other forms of risk-taking. Consequently, this study demonstrates that although frustration based negative-affectivity may promote increased risk-taking, effective cognitive-control functioning can help to regulate and maintain adaptive goal directed outcomes in risk-taking contexts.

This study also found evidence to suggest that the relationship between intelligence and risk-taking is fully mediated by cognitive-control (Figure 1). The result is consistent with prior evidence demonstrating a strong link between intelligence and cognitive-control. For example, the putative neural underpinnings of high intellectual functioning converges with those of cognitive-control including an emphasis on efficiencies in white matter mediated neuronal processing (Neubauer & Fink, 2009), in addition to the active engagement of a fronto-parietal network of brain regions consistent with the cognitive-control network (Jung & Haier, 2007). Our findings are in line with previous notions that cognitive-control functioning is a centrally defining feature of intelligence (Niendam et al., 2012) and the results support the notion that the relationship between intelligence and risk-taking is likely to be explained entirely by the variation in intelligence that is shared with cognitive-control functioning.

The major findings need to be interpreted in light of a number of limitations. For example, the size of the sample was small when compared to other studies using SEM methods. Additionally, the unidimensional measure of risk-taking may cloud interpretation given that this approach can attenuate strong, and strengthen weak, relationships between specific risk behaviors and the predictor variables (Smith, Fischer, & Fister, 2003). A further limitation centers on the cross-sectional design that was employed that precludes any inferences to be drawn about how risk-taking behaviors emerge during adolescence, and whether the maturational trajectory of affective motivations and cognitive-control can predict different trajectories of risk-taking participation. Finally, we did not examine other potential factors that could potentially influence the results such as demographics, family, community, neighborhood and cultural influences.

A major strength of the study was the latent variable modeling approach used for analysis, which accounts for the measurement error inherent in any single observed score by utilizing multiple indicators of latent constructs. This approach was particularly useful for the quantification of risk-taking by providing an estimate of the variation in risk-taking that is common to all risk-taking behaviors which was externally valid given this unidimensional factor structure was replicated in the larger sample (n=4135) of 16 year olds from the 2009 U.S. YRBS study. Similarly, the latent variable approach to quantifying cognitive-control is an advance on previous risk-taking studies by utilizing a multi-method assessment of this construct. Consequently, the increased measurement precision offered by the latent modeling approach permits more robust inferences to be made about the underlying constructs of interest.

In summary, despite converging evidence implicating cognitive-control in moderating the influence of affective motivations on risk-taking behavior, the results of this study found no evidence to support an interaction between *Surgency* and *Cognitive-control* in the prediction of adolescent risk-taking and supports the notion that temperamental positive-affectivity may be associated with risk-taking by increasing an individual's propensity to seek out novel and exciting environments. By contrast, this study provided empirical support for the interaction between *Cognitive-control* and *Frustration* in predicting adolescent risk-taking suggesting that frustration based motivations towards risk-taking can be inhibited by effective cognitive-control processing. This finding has important implications and suggests that although frustration may be a key negative-affectivity variable that motivates towards risk-taking, it is possible that learning how to regulate this emotion can reduce risk taking behaviour. Finally, future studies will benefit on characterising the temporal evolution of these interactions, possibly using ecological momentary assessment methodology. Use of such methods will permit understanding of the temporal relationship between an adolescent's level of frustration, the contexts in which frustrations can occur, and whether these affective states are a cause or consequence of risk-taking behaviour.

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Table 1. Details of Measures and Latent Variable Indicators

Latent Variable and Measures	Latent variable indicators
Risk-taking	
2007 Youth Risk Behavior Survey (CDC, 2004)	Helmet-use, seatbelt-use, fights, suicide-plan, daily-smoking, used illicit drugs, days alcohol use, times cannabis use, sexual partners (+ad hoc item: times-gambled)
Surgency (Positive-Affectivity)	
EATQ-R: Surgency (Ellis & Rothbart, 2001)	High Intensity Pleasure, (low)Shyness, & (low)Fear subscales
Frustration	
EATQ-R: Negative-Affectivity (Ellis & Rothbart, 2001)	Frustration subscale
Cognitive Control	
EATQ-R: Effortful Control (Ellis & Rothbart, 2001)	Attention, Activation Control, & Inhibitory Control subscales
Stroop Colour-Word Interference Task (Carter et al., 2002)	Errors, Reaction Times (mostly incongruent and mostly congruent blocks)
Multisource Interference Task (Bush & Shin, 2006)	Errors, Reaction Times (incongruent and congruent blocks; behavioral data only)
FSIQ (Estimated Full Scale Intelligence)	
Wechsler Intelligence Scale for Children	Vocabulary, Matrix Reasoning and Symbol Search subtests

(Wechsler, 1992)

Note: Descriptions and psychometrics of measures are presented in supplementary material. EATQ-R=Early Adolescent Temperament Questionnaire-Revised

Table 1. Unidimensional Factor Structure of Latent Risk-taking Model for the Current Sample (*N*=174), and Sample of 16-Year-Old Adolescents (*N*=4135) from 2009 Youth Risk Behavior Survey

	Current Sample Loading (residual variance)	YRBS Sample Loading (residual variance)
Helmet riding bike?[a]	**.361** (.870)	**-.046*** (.988)
Wearing seatbelt?	**.493** (.757)	**-.384*** (.853)
In physical fight?	**.498** (.752)	**.591** (.651)
Suicide Plan?	**.445** (.802)	**-.326*** (.894)
Smoke daily?	**.940** (.116)	**-.796*** (.366)
Ever illicit drugs?	**.870** (.243)	**.721** (.480)
Days gambled ever	**.254** (.935)	n.a.
Days had alcohol ever	**.745** (.445)	**.749** (.439)
Cannabis times ever	**.915** (.163)	**.860** (.260)
Sexual partners ever	**.625** (.609)	**.679** (.539)

YRBS=Youth Risk Behavior Survey

Bold font indicates significant loadings (p<.05)

n.a.=not available in 2009 YRBS

*low scores indicative of increased risk-taking

[a]not comparable because differences in legal requirements for helmets in Australia and U.S.

Current sample: (χ^2[19]= 26.91, p=.11; N=174; CFI=.986, RMSEA=.049)

YRBS sample: (χ^2[25]=258.86, p<.001; N=4135; CFI=.972, RMSEA=.048)

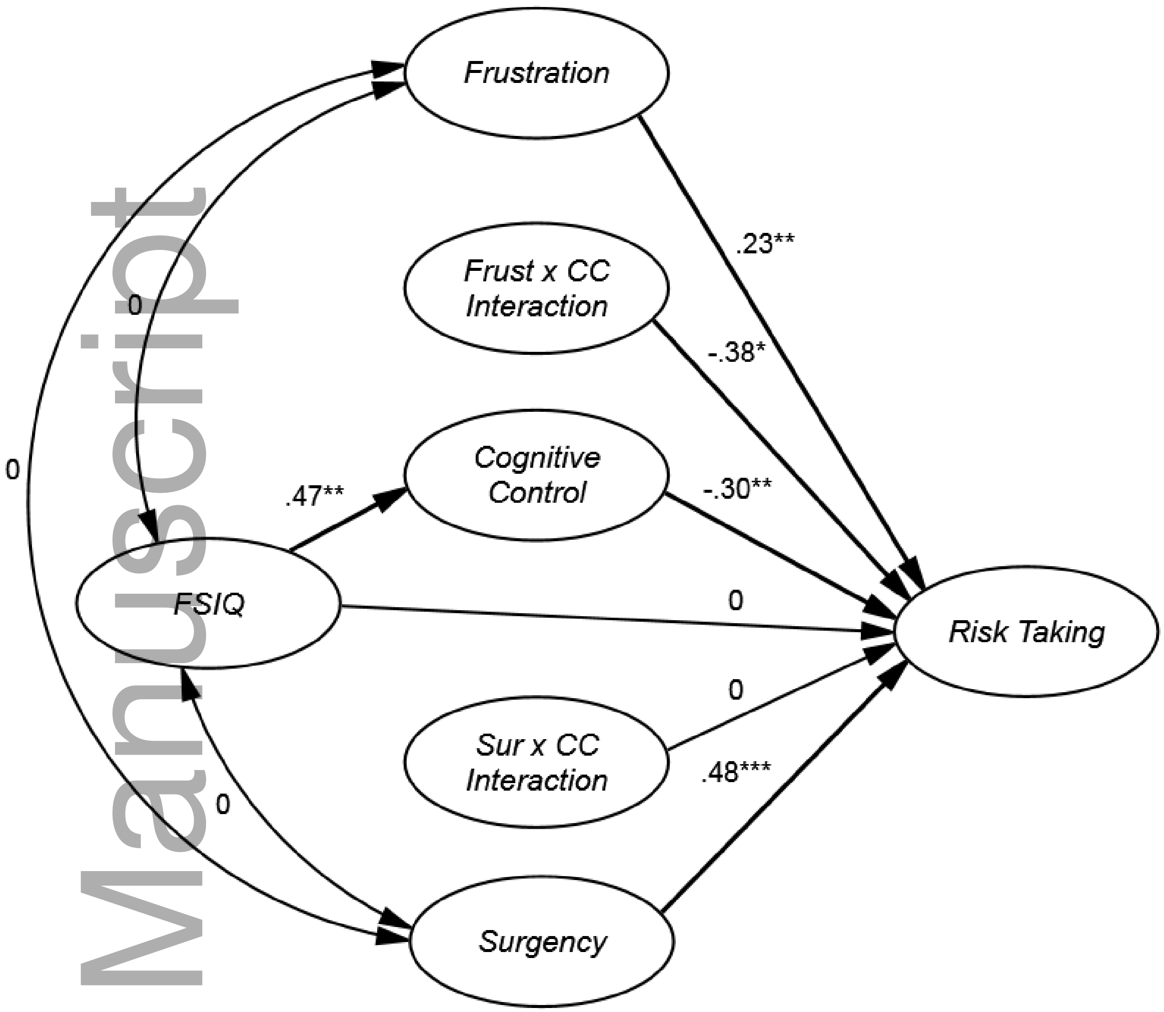

Figure 1. Final structural equation model (*Risk-taking*: r^2=.67; *Cognitive-control:* r^2=.22). Covariances between exogenous variables and regression weights for *Risk-taking* on *Surgency x Cognitive-control* and *FSIQ* were not significant and set to zero (nested models were tested using χ^2 difference tests). All parameters in figure are standardized using Muthén (2012) protocol. The indirect effect of *FSIQ* on *Risk-taking* mediated by *Cognitive-control* was significant (unstandardized *b*=-0.049, 95%CI [-0.079, -0.018], *SE*=0.016, *p*=.002). Indicator variables (not presented in diagram but provided in Table 1 and supplementary material) remained statistically significant indicators of their respective latent variables (indicators for *Surgency* were parallel). *p<.05; **p<.01; ***p<.001. Frust x CC=*Frustration x Cognitive-control*; *FSIQ*=Estimated Full Scale Intelligence; Sur x CC=*Surgency x Cognitive-control*.

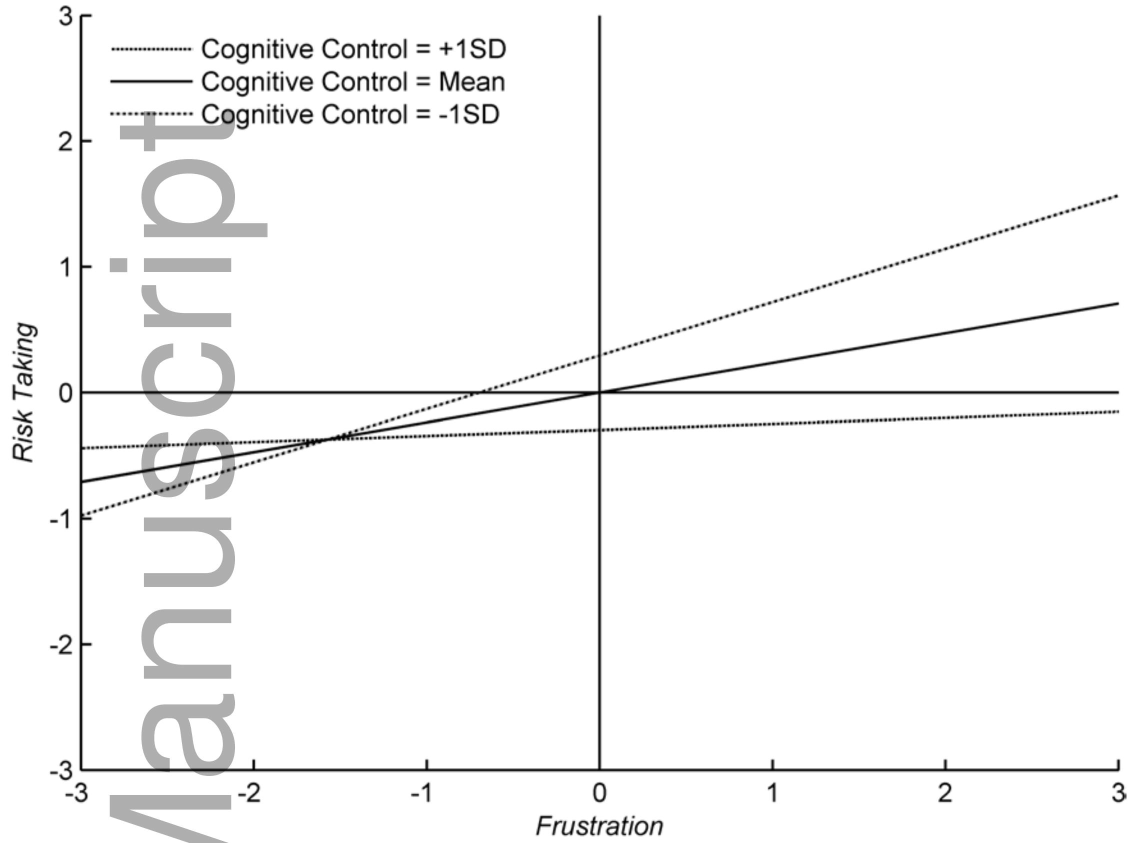

Figure 2. Graphical representation of the significant *Frustration x Cognitive-control* latent variable interaction in predicting *Risk-taking*. This figure demonstrates that the relationship between *Frustration* and *Risk-taking* is attenuated for participants with "above average" cognitive-control functioning (i.e., 1 *SD* above mean cognitive-control score) and magnified in those with "below average" cognitive-control functioning (i.e., 1 *SD* below mean cognitive-control score). Standardized coefficients were utilized.