The association between risky decision making and attention-deficit/hyperactivity disorder symptoms: A preregistered assessment of need for cognition as underlying mechanism

Zadelaar, J.N.; Dekkers, T.J.; Huizenga, H.M.

DOI
10.1002/bdm.2177

Publication date
2020

Document Version
Final published version

Published in
Journal of Behavioral Decision Making

Received: 5 September 2019 | Revised: 7 January 2020 | Accepted: 11 February 2020

DOI: 10.1002/bdm.2177

Check for updates

RESEARCH ARTICLE

WILEY

The association between risky decision making and attention-deficit/hyperactivity disorder symptoms: A preregistered assessment of need for cognition as underlying mechanism

Jacqueline N. Zadelaar[1] | **Tycho J. Dekkers**[1,2,3,4] | **Hilde M. Huizenga**[1,5,6]

[1]Department of Psychology, University of Amsterdam, Amsterdam, The Netherlands

[2]Department of Forensic Psychiatry and Complex Behavioral Disorders, De Bascule, Academic Center for Child- and Adolescent Psychiatry, Amsterdam, The Netherlands

[3]Department of Child and Adolescent Psychiatry, Amsterdam UMC, Free University Medical Center (VUmc), Amsterdam, The Netherlands

[4]Department of Psychology, University of Central Florida, Orlando, Florida

[5]Amsterdam Brain and Cognition Center, University of Amsterdam, Amsterdam, The Netherlands

[6]Research Priority Area Yield, University of Amsterdam, Amsterdam, The Netherlands

Correspondence

Tycho J. Dekkers, Department of Psychology, University of Amsterdam, Nieuwe Achtergracht 129b, Amsterdam, the Netherlands.

Email: t.j.dekkers@uva.nl

Funding information

Prins Bernhard Cultuurfonds, Grant/Award Number: 40021352; Netherlands Organization for Scientific Research (NWO), Grant/Award Number: 453-12-005

Abstract

Attention-Deficit/Hyperactivity Disorder (ADHD) is related to suboptimal decision making in experimental tasks and to real-life risk-taking behavior (RTB) such as substance abuse and unsafe traffic conduct. In this preregistered study, we tested whether these associations are mediated by need for cognition—the extent to which one tends towards, and enjoys, analytical thought. In a large sample of young adults (N = 463, M_{age} = 19.7 years), we tested whether need for cognition mediated the association between self-reported ADHD symptoms on the one hand and decision-making strategy complexity on an experimental gambling task and self-reported real-life RTB on the other hand. Preregistered confirmatory analyses indicated first that ADHD symptoms were positively associated with real-life RTB, but the association was not mediated by need for cognition. Second, ADHD symptoms were not related to decision-making strategy complexity, and need for cognition was not a significant mediator. Explorative analyses revealed that (a) need for cognition was associated with higher decision-making accuracy and slower reaction time; (b) need for cognition was related to inattentive but not to hyperactive/impulsive ADHD symptoms; (c) need for cognition was associated with health-related RTB but not interpersonal RTB; and (4) only the association between inattention and health-related RTB was mediated by need for cognition. We conclude that need for cognition is not a mediator in the association between ADHD symptoms and RTB. Additionally, we conclude that neither ADHD symptoms nor need for cognition predict decision-making strategy complexity. Implications for both future research and clinical practice are discussed.

KEYWORDS

need for cognition, decision making, attention-deficit/hyperactivity disorder (ADHD), risk-taking behavior, gambling task, mediation

Authors Jacqueline N. Zadelaar and Tycho J. Dekkers contributed equally.

1 | INTRODUCTION

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder, characterized by high levels of inattention, hyperactivity, and impulsivity that lead to significant impairment across settings (American Psychiatric Association, 2013). The prevalence of ADHD is high, with prevalence rates of 5.9–7.2% in children and adolescents, 2.5–5% in adults, and 2–8% in college students (DuPaul, Weyandt, O'Dell, & Varejao, 2009; Thomas, Sanders, Doust, Beller, & Glasziou, 2015; Willcutt, 2012). ADHD is not only associated with individual impairment, the financial burden on society is large as well (Robb et al., 2011; Zhao et al., 2019). A substantial part of these costs is related to risk-taking behavior (RTB), which is increased in individuals with ADHD (Nigg, 2013). For example, ADHD is associated with substance abuse, traffic incidents, delinquency, sexual RTB, and unhealthy eating (see Pollak, Dekkers, Shoham, & Huizenga, 2019 for a review). Several recent meta-analyses comparing individuals with ADHD to controls on experimental decision-making tasks are in line with the findings on real-life risk taking: Individuals with ADHD are characterized by more risky, impulsive, and generally suboptimal (i.e., choosing the least favorable option more frequently) decision making (Dekkers et al., 2018; Dekkers, Popma, Agelink van Rentergem, Bexkens, & Huizenga, 2016; Mowinckel, Pedersen, Eilertsen, & Biele, 2015; Patros et al., 2016). Therefore, understanding the mechanisms that drive ADHD-related RTB is crucial.

ADHD-related suboptimal decision making may be associated with the use of suboptimal decision strategies (Dekkers et al., 2019). A decision strategy, which is a method of information processing to reach a decision (Payne, 1976; Payne, Bettman, Johnson, & Luce, 1995), can vary in complexity depending on the amount of information utilized and the way in which this is processed (Jansen, van Duijvenvoorde, & Huizenga, 2012). For example, the decision between a certain gain of $25,– and a 50/50 probability of gaining $100,– or losing $25,– can be made using several strategies. The most complex strategy would be to compute and compare the expected value (EV = gain × P(gain)+ loss × P(loss)) of options, thus using all available information in a computationally complex manner (Montgomery & Adelbratt, 1982; Rolls, McCabe, & Redoute, 2008). This would lead one to prefer the second option (EV= $37,50) over the first (EV= $25,–). An alternative would be to use a heuristic, a simple decision strategy on the basis of incomplete information. For example, in the "take-the-best" heuristic, options are compared only on the (subjectively) most valued, sufficiently discriminating attribute (Dietrich, 2010; Gigerenzer & Gaissmaier, 2011; Graefe & Armstrong, 2012; Hardman & Hardman, 2009; Newell, Lagnado, & Shanks, 2007). For example, if this attribute is amount of loss, this strategy presents the first option as superior. Less complex strategies may lead to suboptimal decisions but require less cognitive effort, which may be preferable when the cognitive demand is large or when motivation to invest cognitive effort is lacking (Kool, McGuire, Rosen, & Botvinick, 2010; Payne, Bettman, & Johnson, 1988; van Duijvenvoorde et al., 2016).

More complex decision making puts a greater demand on executive functioning (Bexkens, Jansen, Van der Molen, & Huizenga, 2016; DeStefano & LeFevre, 2004; Stewart, 2009). The links between ADHD and deficits in executive functions such as inhibition (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005) and working memory (Kasper, Alderson, & Hudec, 2012) are firmly established. It is thus likely that individuals with ADHD demonstrate different, less complex decision strategies than typically developing individuals. For example, ADHD is characterized by a reduced ability to apply decision rules of varying complexity, which was ascribed to the extensively required cognitive demand (Dekkers et al., 2019; Mäntylä, Still, Gullberg, & Del Missier, 2012). Therefore, we hypothesize that suboptimal decision making observed in ADHD (Dekkers et al., 2016) is attributable to the use of less complex decision strategies.

Suboptimal decision making may originate in a lower need for cognition. Need for cognition describes the extent to which one tends towards, and enjoys, analytical thought (Cacioppo & Petty, 1982; Cacioppo, Petty, & Feng Kao, 1984). Previous research revealed that individuals with a higher need for cognition make more rational decisions (Curseu, 2006), use more of the available information in their decision making (Nair & Ramnarayan, 2000; Verplanken, 1993), and are less susceptible to framing effects (Smith & Levin, 1996). This has been attributed to a positive association between need for cognition and information processing depth (Chatterjee, Heath, Milberg, & France, 2000; Simon, Fagley, & Halleran, 2004). Indeed, individuals with a low need for cognition were found to expend less cognitive effort during decision making and resort to simplistic decision strategies under time pressure more frequently, relative to individuals with a high need for cognition (Verplanken, 1993). This suggests that low need for cognition indeed relates to the use of suboptimal strategies.

Given that need for cognition positively relates to information processing depth, we conjecture that individuals low in need for cognition may underestimate potential negative outcomes, which has been related to increased RTB (Figner, Mackinlay, Wilkening, & Weber, 2009; Figner & Weber, 2011). This is supported by a study that found that individuals low in need for cognition performed worse at the Iowa Gambling Task because they were more sensitive to gains than to losses (Harman, 2011). In another study, individuals high in need for cognition displayed avoidance and minimization of negative outcomes (when decision difficulty was emphasized), whereas individuals low in need for cognition were largely unaffected (Steinhart & Wyer, 2009). Additionally, low need for cognition has been associated with reduced effectiveness of persuasive pro-health messages (e.g., promoting mammography for early cancer detection), along with a dislike for more complex messages in general, and an increased likelihood of ignoring details therein (Ruiter, Verplanken, De Cremer, & Kok, 2004; Schmid, Rivers, Latimer, & Salovey, 2008; Williams-Piehota, Schneider, Pizarro, Mowad, & Salovey, 2003). We therefore hypothesize that low need for cognition relates to increased RTB.

ADHD is likely characterized by lower need for cognition. This is implied by the Diagnostic and Statistical Manual of Mental Disorders 5 specification of "a reluctance to engage in activities that require mental effort" as ADHD symptom (American Psychiatric Association, 2013). Also, children and adolescents with ADHD used less effortful strategies in learning relative to controls (Egeland, Johansen, & Ueland, 2010), and differences between individuals with and without ADHD typically increase when the cognitive load of the task increases (Kofler, Raiker, Sarver, Wells, & Soto, 2016; Vaurio, Simmonds, & Mostofsky, 2009), potentially because of problems in investing mental effort. This is in agreement with several contemporary models of ADHD. According to Sergeant's (2005) influential cognitive-energetic model, effort allocation is one of the core deficits related to ADHD. Others would argue that it is the particularly aversive nature of the delay associated with cognitively demanding tasks that would account for a lower need for cognition in children and adolescents with ADHD (Sonuga-Barke, 2005). Motivational theories state that individuals with ADHD need higher levels of reinforcement than individuals without ADHD to apply the same level of cognitive effort (Dovis, Van der Oord, Wiers, & Prins, 2012; Luman, Oosterlaan, & Sergeant, 2005).

Although the link between ADHD and lower need for cognition seems plausible, the current preregistered study is the first study to directly test whether young adults with more ADHD symptoms demonstrate lower need for cognition. Crucially, we also investigated whether lower need for cognition mediated the effect of ADHD symptoms on both the complexity of decision making, as well as real-life RTB. That is, ADHD symptoms were expected to be negatively associated with need for cognition; need for cognition was expected to be positively related to decision-making strategy complexity (from now: decision-making complexity) and negatively related to real-life RTB.

ADHD symptomatology was measured dimensionally as this has several advantages over categorical case–control designs. First, several lines of evidence suggest that ADHD has a dimensional structure (for a review, see Coghill & Sonuga-Barke, 2012). Second, dimensional measures of ADHD have been repeatedly associated with RTB (Dekkers, Huizenga, Bult, Popma, & Boyer, n.d.; Shoham, Sonuga-Barke, Aloni, Yaniv, & Pollak, 2016; Spiegel & Pollak, 2019). Third, case–control designs as compared with dimensional measurements are associated with reduced power (Royston, Altman, & Sauerbrei, 2006).

2 | METHODS

2.1 | Participants

This study was preregistered using the AsPredicted template on Open Science Framework. The preregistration can be found on https://osf.io/tfrcx/. Therefore, all analyses are confirmatory unless indicated otherwise.

Participants were 463 first-year psychology students (71.5% females, M_{age} = 19.7 years) from the University of Amsterdam, the Netherlands. Their participation was part of a larger test administration, spanning for two sessions of 160 min each. The study was approved by the local Institutional Review Board, and all participants gave active consent.

According to Fritz and MacKinnon (2007), to detect small to medium-small effect sizes with a power of .8, a sample size between 162 and 558 participants is required, depending on the size of both paths making up the mediation (i.e., independent variable on mediator and mediator on dependent variable).

2.2 | Materials

ADHD symptoms were measured with the Adult ADHD Self-Report Scale (ASRS; DuPaul, Power, Anastopoulos, & Reid, 1998). On each of the 18 items, participants indicated on a 5-point Likert scale how frequently certain behaviors occurred in the past 6 months (i.e., "How often do you have problems remembering appointments or obligations?"). Higher scores indicate the presence of more ADHD symptoms. The ASRS has good psychometric properties (DuPaul et al., 1998) and is highly accurate in distinguishing clinical ADHD from nonclinical or subclinical ADHD Diagnostic and Statistical Manual of Mental Disorders IV classifications (Adler et al., 2012; Kessler et al., 2005). In the current sample (N = 463), internal consistency was good for the total scale (α = .80) as well as its factors (inattention, hyperactivity, and impulsivity). ASRS total scores were normally distributed, supporting our dimensional approach on ADHD. However, ASRS factor scores were slightly right skewed. For details, see supporting information.

Need for cognition was measured with the short form of the Need for Cognition Scale (NCS; Cacioppo et al., 1984), an 18 item self-report questionnaire that inquires interest in cognitively effortful tasks. Participants indicated on a 5-point Likert scale to what extent each given statement (e.g., "I would prefer complex to simple problems") was characteristic of them. Higher scores indicate more need for cognition. The NCS has good psychometric properties (Cacioppo, Petty, Feinstein, & Jarvis, 1996; for an overview, see Lins de Holanda Coelho, Hanel, & Wolf, 2018), and in the current sample, internal consistency was good (α = .85).

RTB was measured using the Risk Taking Questionnaire (RTQ), a 28-item Dutch self-report questionnaire concerning the frequency of engagement in risky behaviors (e.g., "Smoking cigarettes") in the past 4 weeks, as indicated on a 5-point Likert scale. We designed this questionnaire recently for use in an adolescent sample on the basis of the risk behavior questionnaire (Pat-Horenczyk et al., 2007), the adolescent version of the domain-specific risk-taking (Blais & Weber, 2006) and the ADorTI (Pollak & Aran, (n.d.), ADorTI (personal communication)). Two items from the recently created RTQ were deleted ("Run away from home" and "Staying out after curfew") because these were deemed inappropriate given the age of the current student sample, and one item was deleted because it correlated negatively with the total score of the questionnaire in another (yet unpublished) study. Higher scores indicate increased RTB. The internal consistency in the current sample was good (α = .75).

Decision-making strategy was measured using the gambling machine task (GMT; Jansen et al., 2012), a task frequently used to establish decision-making strategies (e.g., Bexkens et al., 2016;

Dekkers et al., 2019). The task features mixed gambles with certain gains and probabilistic losses, similar to other decision-making tasks like the Iowa gambling task (Bechara, Damasio, Damasio, & Anderson, 1994) and the Balloon Analogue Risk Task (Lejuez et al., 2002). Mixed gambles with both gain and losses are ecologically more valid than gambles with either gains or losses. Moreover, they provide more attributes on which the alternatives may vary, which increases maximum decision complexity and thus prevents ceiling effects. The GMT contained 40 items (20 items, twice repeated) wherein participants indicated which of two depicted gambling machines was most optimal. For each item, the two gambling machines varied on at least one to maximally three possible attributes: (a) amount of certain gain, (b) amount of loss, and (c) frequency of loss (i.e., the probability of loss; further note that the gain was always certain so therefore all gambling machines have the same probability of gain). An example of the GMT can be found in Figure 1.

Participants were instructed to choose the most favorable machine (see supporting information for participant instructions). If participants perceived both machines equally favorable, they could also respond "does not matter". No postdecision feedback was provided. An answer was considered correct when the participants chose the gambling machine with the highest EV. On 8 of the 40 items, EVs were equal; hence, the correct answer was "does not matter." Higher scores indicate more optimal decision making.

By item–response patterns, we can distinguish 18 decision strategies (see Table 1) congruent with lexicographic or compensatory decision rules (Gigerenzer & Goldstein, 1999; Hauser, 2014; Hauser, Ding, & Gaskin, 2009; Jansen et al., 2012; van Duijvenvoorde et al., 2016). Strategy distinction stems from four strategy characteristics: (a) the number of attributes considered (between zero and three), (b) the nature of considered attributes (gain, loss, and/or probability), (c) the order in which these are considered, and (d) the complexity of mental computations performed on the attributes (e.g., guess, compare, and multiply).

Complexity scores were first defined by the number of attributes involved, with strategies involving more attributes being considered more complex. As the guessing strategy involved none of the available attributes, it was considered simplest. Following the same logic, simple strategies (which involve a single attribute) were considered less complex than two-attribute sequential strategies, which were less complex than three-attribute sequential strategies.

The second criterion of strategy complexity was the complexity of mental computations, with integration followed by comparison being considered more complex than simple comparison. As such, the integrative and semi-integrative strategies were considered more complex than three-attribute sequential strategies. Finally, integration involving more attributes was considered more complex, making the integrative strategy more complex than the semi-integrative strategy. This resulted in complexity scores varying from 1 (*guessing*) to 6 (*computing EV in the integrative strategy*).

Differential decision-making strategy use was estimated via a model-based latent-mixture analysis using Bayesian inference, introduced in Steingroever, Jepma, Lee, Jansen, and Huizenga (2019). Building on earlier methods such as rule-assessment analysis (Siegler, Strauss, & Levin, 1981) and latent-mixture analysis (Huizenga, Crone, & Jansen, 2007; Jansen & Van der Maas, 1997, 2002), this method simultaneously infers the number and size of strategy groups (i.e., groups of individuals using the same strategy). More specifically, the method operates by assuming that each participants' responses to GMT items are generated by one of the decision-making strategies, each of which predicts a specific item–response pattern. Each individual can deviate from the predicted pattern according to an individual error rate ($\in_i$). Parameter z_i denotes the decision strategy assigned to participant *i*. Individuals were inferred to have used the strategy most frequently assigned across iterations (i.e., the most common value in parameter z_i). The method introduced in Steingroever et al. (2019) was expanded in the current study to include a semi-integrative decision-making strategy (the full code can be found on https://osf.io/ptd5b/). For details on chosen convergence checks, we refer to https://osf.io/tfrcx/.

2.3 | Procedure

Participants completed the questionnaires and the task on a computer as part of a larger test session. The GMT was administered first, followed by the RTQ, the ASRS, and the NCS. Performance was incentive compatible; after administration, five participants were

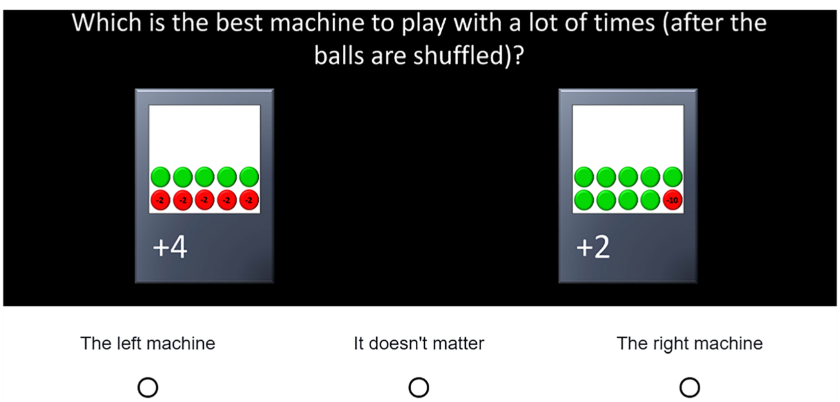

FIGURE 1 An example of a gambling machine task item: the positive white number on the machine indicates the amount of certain gain (CG), the negative number in the red ball(s) indicate(s) amount of loss (AL), and the number of red balls divided by the total number of balls in the machine indicates the frequency of loss (FL). Using the integrative decision-making strategy, one would calculate the expected value (EV) of each machine as EV = CG – (AL × FL). As such, $\text{EV}_{\text{left}} = 4 - \left(2 \times \frac{5}{10}\right) = 3$ and $\text{EV}_{\text{right}} = 2 - \left(10 \times \frac{1}{10}\right) = 1$, indicating that the left machine is more favorable [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 1 Decision-making strategies and assigned complexity ratings

	Strategy type	Attributes	Description: decisions made on the basis of …	Complexity
1	Guessing	-	Randomly selecting choice options	1
2	Simple	FL	Frequency of loss	2
3	Simple	AL	Amount of loss	2
4	Simple	CG	Amount of certain gain	2
5	Sequential	FL > AL	Frequency of loss, if that fails amount of loss	3
6	Sequential	FL > CG	Frequency of loss, if that fails amount of certain gain	3
7	Sequential	AL > FL	Amount of loss, if that fails frequency of loss	3
8	Sequential	AL > CG	Amount of loss, if that fails amount of certain gain	3
9	Sequential	CG > FL	Amount of certain gain, if that fails frequency of loss	3
10	Sequential	CG > AL	Amount of certain gain, if that fails amount of loss	3
11	Sequential	FL > AL > CG	Frequency of loss, if that fails amount of loss, if that fails amount of certain gain	4
12	Sequential	FL > CG > AL	Frequency of loss, if that fails amount of certain gain, if that fails amount of loss	4
13	Sequential	AL > FL > CG	Amount of loss, if that fails frequency of loss, if that fails amount of certain gain	4
14	Sequential	AL > CG > FL	Amount of loss, if that fails amount of certain gain, if that fails frequency of loss	4
15	Sequential	CG > FL > AL	Amount of certain gain, if that fails frequency of loss, if that fails amount of loss	4
16	Sequential	CG > AL > FL	Amount of certain gain, if that fails amount of loss, if that fails frequency of loss	4
17	Semi-integrative	(FL × AL) > CG	Expected value of loss, if that fails use gain amount	5
18	Integrative	CG − (FL × AL)	Expected value	6

Note. Strategies range from the most basic (i.e., guessing) to simple (i.e., consider only one attribute), to sequential (i.e., consider several attributes sequentially), to semi-integrative (i.e., sequentially consider expected loss, then certain gain), and to integrative (i.e., consider expected value). Considered attributes are shown.
Abbreviations: AL, amount loss; CG, certain gain; FL, frequency loss.

randomly selected to receive a reward on the basis of the mean EV of the gambling machines they selected on the GMT. Rewards ranged between €5,– and €25,–.

2.4 | Data analysis

We tested two mediation models.[1] First, we tested if ADHD symptoms (ASRS score and continuous) predicted RTB (RTQ score and continuous) directly and indirectly via need for cognition (NCS score and continuous). Second, we tested if ADHD symptoms predicted decision-making complexity (continuous) directly and indirectly via need for cognition. For both mediation analyses, we used the PROCESS macro in SPSS (Hayes, 2018), Model 4, using standardized variables and 5,000 bootstrap samples.

On the GMT, participants were excluded if more than 20% of the easy items (i.e., 12 items where only one of the three attributes differed between both machines) were answered incorrectly, as this indicated no understanding of the task. Additionally, participants who spent less than 20% of the estimated time on the self-report questionnaires (i.e., <1 min) were excluded. These exclusion criteria were preregistered.

For the self-report questionnaires, outliers were detected on the basis of absolute deviation around the median using a threshold of 2.5 times the median absolute deviation (Leys, Ley, Klein, Bernard, & Licata, 2013). All analyses were run twice, once including and once excluding outliers, to see if and how the outliers influenced results. Both analyses are reported.

3 | RESULTS

3.1 | Decision-making complexity assignment

The number of participants assigned to each decision-making complexity score can be found in Table 2. The majority of participants (92.0%) was assigned to one of the three most complex scores.

[1]There is considerable debate on the topic of mediation (see Hayes, 2018; Maxwell, Cole, & Mitchell, 2011). By using this term, we certainly do not intend to make causal inferences. In the current investigation, mediation can be interpreted as an indirect effect.

TABLE 2 The number of participants assigned to each decision-making complexity score

Decision-making complexity	*n*
1. Guessing	12
2. Simple	2
3. Sequential (two attributes)	24
4. Sequential (three attributes)	177
5. Semi-integrative	116
6. Integrative	132
Total	463

3.1.1 | Does need for cognition mediate the link between ADHD symptoms and decision-making complexity?

For the mediation analysis with decision-making complexity as dependent variable, 37 participants were excluded because they responded too fast on the ASRS (n = 3), NCS (n = 5), or they made too many mistakes on the simple GMT items (n = 35). Given that several participants met multiple exclusion criteria, the sum of these numbers exceeds the total number of excluded participants, resulting in a final sample size of N = 426. In this sample, 10 outliers were detected on the ASRS (n = 4) and/or NCS (n = 7). One participant had an outlying score on both measures. The final sample size excluding outliers was N = 416.

The results of the mediation analysis are depicted in Figure 2. The total effect of ADHD symptoms predicting decision-making complexity was not significant, b = .02, $t(424)$ = 0.41, and p = .68. This did not change after taking into account need for cognition as mediator, b = .02, $t(423)$ = 0.46, and p = .64.

ADHD symptoms did not predict need for cognition, b = −.05, $t(424)$ = −1.10, and p = .27. Need for cognition did not significantly predict decision-making complexity, b = .05, $t(423)$ = 1.03, and p = .30. Finally, the indirect effect was not significant, as the bootstrap derived 95% confidence interval contained 0 [−0.014, 0.004], indicating that ADHD did not predict decision-making complexity via need for cognition.

After excluding 10 outliers, results were almost similar; no effects changed in terms of significance (see Figure S3). Taken together, these results indicate that none of the expected effects were observed. That is, ADHD symptoms did not negatively predict need for cognition or decision-making complexity, need for cognition did not positively predict decision strategy complexity, and need for cognition did not mediate the expected negative association between ADHD symptoms and decision-making complexity.

3.1.2 | Does need for cognition mediate the link between ADHD symptoms and RTB?

For the mediation analysis with RTB as dependent variable, 18 participants were excluded for responding too fast on the ASRS (n = 3), RTQ (n = 14), and/or NCS (n = 5). Again, some of these participants were too fast on multiple questionnaires, causing the sum of these numbers to exceed the number of excluded participants. This led to a final sample of N = 445. In this sample, 17 outliers were detected on the ASRS (n = 5), RTQ (n = 6), and/or NCS (n = 7). Note that one participant had an outlying score on two measures. The final sample size excluding outliers was N = 428.

The results of the first mediation analysis are depicted in Figure 3. ADHD symptoms predicted RTB, b = .39, $t(443)$ = 8.97, and p < .001 (i.e., total effect). In other words, more ADHD symptoms were associated with increased RTB. This effect remained when need for cognition was added as a mediator, b = .40, $t(442)$ = 9.16, and p < .001.

ADHD symptoms did not predict need for cognition, b = −.07, $t(443)$ = −1.48, and p = .14. However, need for cognition did predict RTB, b = .10, $t(442)$ = 2.38, and p = .02. Adolescents reporting more need for cognition also reported more, instead of less, RTB. The indirect effect was not significant, as the bootstrap-derived 95% confidence interval contained 0 [−0.024, 0.003], that is, the association between ADHD and RTB was not mediated by need for cognition.

Excluding outliers, results were almost similar; no effects changed in terms of significance (see Figure S4). Taken together, ADHD symptoms indeed were related to RTB. However, neither the hypothesized link between ADHD symptoms and need for cognition nor the hypothesized mediation were supported. Moreover, contrary to expectations, higher need for cognition was related to increased instead of decreased RTB.

3.2 | Explorative analyses

ADHD is a heterogeneous disorder (Martel, Goth-Owens, Martinez-Torteya, & Nigg, 2010; Sonuga-Barke, 2005; Wåhlstedt, Thorell, &

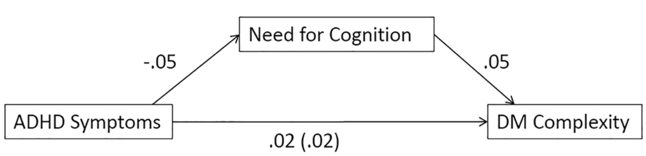

FIGURE 2 Mediation model: standardized regression coefficients for the association between attention-deficit/hyperactivity disorder (ADHD) symptoms and decision-making (DM) strategy complexity as mediated by need for cognition. The total effect is in parentheses

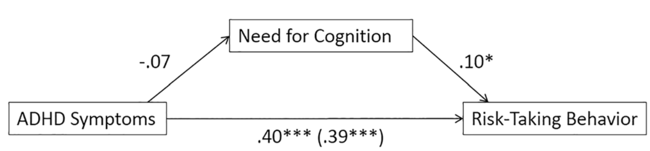

FIGURE 3 Mediation model: standardized regression coefficients for the association between attention-deficit/hyperactivity disorder (ADHD) symptoms and risk-taking behavior as mediated by need for cognition. The total effect is in parentheses. $^{*}p < .05$. $^{***}p < .001$

TABLE 3 Effects (standardized coefficients) of explorative mediation analyses

Model		Effects				
		IV → DV (total effect)	IV → DV (direct effect)	IV → M	M → DV	IV → M → DV (indirect effect)
1	IV = inattention M = NC DV = DMSC	.068	.074	−.103*	.058	95% CI [−0.020, 0.004]
2	IV = hyperactivity M = NC DV = DMSC	−.063	−.059	−.082	.045	95% CI [−0.017, 0.005]
3	IV = impulsivity M = NC DV = DMSC	.026	.023	.066	.049	95% CI [−0.005, 0.014]
4	IV = inattention M = NC DV = IRTB	.243***	.253***	−.138**	.071	95% CI [−0.029, 0.002]
5	IV = hyperactivity M = NC DV = IRTB	.202***	.208***	−.092	.056	95% CI [−0.020, 0.003]
6	IV = impulsivity M = NC DV = IRTB	.258***	.256***	.064	.020	95% CI [−0.006, 0.010]
7	IV = inattention M = NC DV = HRTB	.330***	.347***	−.138**	.125**	95% CI [−0.039, −0.002][a]
8	IV = hyperactivity M = NC DV = HRTB	.294***	.304***	−.092	.105*	95% CI [−0.027, 0.001]
9	IV = impulsivity M = NC DV = HRTB	.355***	.352***	.064	.054	95% CI [−0.003, 0.016]

Abbreviations: DMSC, decision-making complexity; DV, dependent variable; HRTB, health-related risk-taking behavior; IRTB, interpersonal risk-taking behavior; IV, independent variable; M, mediator; NC, stion.
[a]indicates a 95% confidence interval not containing zero.
*p < .05. **p < .01. ***p < .001.

Bohlin, 2009) consisting of multiple distinguishable domains (Caci, Bouchez, & Baylé, 2009; Hesse, 2013; Kim, Lee, & Joung, 2013; Reuter, Kirsch, & Hennig, 2006). Similarly, distinct domains may exist in RTB (e.g., recreational and financial RTB, see Hanoch, Johnson, & Wilke, 2006). If a construct is explained by multiple factors, then a single total sum score may not represent variability in the data as good as scores on each distinct factor (i.e., measured construct) and possibly these factors relate to one another differently than do overall ADHD symptoms and RTB scores. To account for this, a factor analysis is applied to the data of both questionnaires, the ASRS and RTQ, revealing the number of constructs measured by each. Need for cognition is expected to be unidimensional (Cacioppo et al., 1984) but is subjected to the same methods for uniformity.

An exploratory factor analysis was performed on the ASRS data in Mplus (Muthén & Muthén, 2017), comparing a 1- to 5-factor model, using the default oblique GEOMIN rotation (Muthén & Muthén, 2012). The number of underlying factors was dictated by the best fitting model, as based on the Bayesian information criterion (Bhat & Kumar, 2010; Schwarz, 1978). Lower Bayesian information criterion values indicate a better model fit. Yielded factor loadings were multiplied with item scores to calculate a new, weighed sum score for each of the resulting factors. The same was done for the RTQ and NCS data.

In the decision-making data set (N = 426), a 3-factor model was found to explain the ASRS data best. The first factor had the highest loadings on items pertaining to attention (e.g., Item 2, “How often do you have difficulty getting things in order when you have to do a task that requires organization?”), the second factor on items concerning hyperactivity (e.g., Item 13, “How often do you feel restless or fidgety?”), and the third factor on items about impulsivity (e.g., Item

16, “When you're in a conversation, how often do you find yourself finishing the sentences of the people you are talking to, before they can finish them themselves?”). The NCS data were best explained by a 1-factor solution, namely, need for cognition.

In the RTB data set (N = 445), factor analyses revealed that the ASRS and NCS data were best explained by a 3- and 1-factor model, respectively. As factor loadings were similar to those reported in the decision-making data set, these factors were assigned the same interpretation. The RTQ data were best explained by a 2-factor model. On the basis of factor loadings, the first factor appeared to represent behavior with interpersonal risks (e.g., “Lying to parents or friends” or “Disobeying authorities”), whereas the second factor pertained more to behavior associated with health-related risks (e.g., “Cycling/driving under the influence of alcohol/drugs” or “Smoking cigarettes”). The exact results of the factor analyses, including factor loadings, can be found in the supporting information.

Separate mediation analyses were performed wherein inattention, impulsivity, or hyperactivity (standardized scores) predicted either decision-making complexity (see Table 3, Models 1–3) or interpersonal or health-related RTB (see Table 3, Models 4–9) directly and indirectly via need for cognition. We used separate mediation analyses rather than testing all effects of interest in one model, as the latter would produce conditional effects. That is, the regression weight (i.e., effect) of a single independent variable would depend on its correlation with other independent variables (Alexopoulos, 2010; Ziglari, 2017), as well as potential correlations between dependent variables (Field, 2013). This would give rise to complex interpretations, which would be unwarranted given the purely explorative nature of these analyses. No multiple testing corrections were applied as these analyses are purely explorative, intended only to generate rather than test research hypotheses (Bender & Lange, 2001; Rothman, 1990; Streiner & Norman, 2011).

All effects in mediation analyses involving decision-making complexity were nonsignificant (see Table 3, Models 1–3), except that inattention negatively predicted need for cognition. This lack of effects brought forth the question if ADHD symptoms and need for cognition were even related to GMT performance. As such, two exploratory linear regression analyses were performed to see how ADHD symptoms or need for cognition related to GMT accuracy and reaction time.[2] ADHD symptoms did not significantly predict GMT performance, b = .01, $t(423)$ = 0.22, and p = .82; or GMT reaction time, b = .08, $t(423)$ = 1.65, and p = .10. However, need for cognition did predict both GMT performance, b = .14, $t(423)$ = 2.82, and $p < .01$; and reaction time, b = .19, $t(423)$ = 3.88, and $p < .001$. This suggests that increased need for cognition results in better GMT performance and longer reaction times.

Inattention, hyperactivity, and impulsivity positively predicted both interpersonal and health-related RTB (total effect), even when taking into account the effect of need for cognition (direct effect; see Model 4–9 in Table 3). Inattention, but not hyperactivity or impulsivity, negatively predicted need for cognition. Need for cognition positively predicted health-related RTB in analyses wherein either inattention or impulsivity was also included in the model. Finally, the effect of inattention on health-related RTB was negatively mediated by need for cognition (indirect effect). That is, increased inattention predicted decreased need for cognition, but, counterintuitively, need for cognition positively predicted health-related RTB. These results suggest that all facets of ADHD relate to RTB, but only the association between inattention and health-related RTB is mediated by need for cognition, although in a counterintuitive way.

[2]For these explorative analyses on reaction time, we used mean reaction times within participants across GMT items.

4 | DISCUSSION

This is the first study to investigate whether need for cognition (i.e., the extent to which one tends towards, and enjoys, analytical thought; Cacioppo & Petty, 1982; Cacioppo et al., 1984) mediates the associations between ADHD symptoms and suboptimal decision making (Dekkers et al., 2018, 2016; Mowinckel et al., 2015; Patros et al., 2016), as well as RTB (Nigg, 2013; Pollak et al., 2019). ADHD symptomatology was expected to relate to reduced need for cognition that in turn was expected to result in the use of less complex decision-making strategies and increased RTB, presumably due to a diminished tendency to consider all relevant information.

Confirmatory preregistered analyses revealed that both ADHD symptoms and need for cognition were unrelated to decision-making complexity. Consequently, need for cognition did not mediate the association between ADHD and decision-making complexity. The absence of an association between decision-making strategy and ADHD symptoms may be interpreted in two ways. First, self-evidently, that there is no such association, thereby contradicting earlier findings (Dekkers et al., 2016; Mäntylä et al., 2012; Masunami, Okazaki, & Maekawa, 2009). Second, decision-making deficits may predominantly be apparent in the most severe end of the continuum of ADHD symptoms, which is possibly underrepresented in the current sample. Future studies in a broader sample are needed to test the latter interpretation.

Explorative analyses revealed that need for cognition related to more accurate decision-making performance and slower reaction times. As this could not be attributed to the use of more complex decision-making strategies, it may instead be indicative of an association between need for cognition and the complexity of the selection process of a decision-making strategy. Potentially, individuals high in need for cognition select the most efficient (i.e., least complex yet accurate) strategy per decision (a selection process which in itself is effortful), whereas those lower in need for cognition settle on the same strategy for all decisions (which is less effortful). Identifying the most efficient strategy per decision would likely add to the reaction time but may prevent errors during the decision-making process itself, thus increasing accuracy. This explanation is consistent with longer reaction times and increased decision accuracy as observed in the data, as well as earlier findings that individuals high in need for cognition vary more in the amount of information accessed during decision making (Verplanken, 1993). We therefore speculate that need for cognition may be associated with the complexity of the selection of a decision-making strategy.

In accordance with expectations, ADHD symptoms positively predicted RTB, suggesting that more ADHD symptoms are associated with more real-life RTB. The association between ADHD symptoms and RTB was confirmed by all subsequent exploratory analyses on different symptom clusters of ADHD and different forms of RTB: inattention, hyperactivity, and impulsivity were independently found to predict both interpersonal (e.g., stealing) and health-related (e.g., substance abuse) RTB positively. These findings align with a wealth of literature showing increased real-life RTB like substance abuse, risky driving, gambling, antisocial behavior, and unsafe sex in ADHD populations (see Nigg, 2013; Pollak et al., 2019 for reviews on ADHD and RTB). Additionally, these findings suggest that the association between ADHD and RTB is not limited to a specific cluster of ADHD symptoms or a certain dimension of RTB.

Against expectations, ADHD symptoms were unrelated to need for cognition, need for cognition was associated with increased rather than decreased RTB, and the effect of ADHD symptoms on RTB was not mediated by need for cognition. Explorative analyses indicated that need for cognition was only associated to increased, instead of decreased, health-related RTB. In personality literature, need for cognition is linked to other traits like openness to new ideas and experiences (Fleischhauer et al., 2010; Sadowski & Cogburn, 1997; Tuten & Bosnjak, 2006), curiosity (Olson, Camp, & Fuller, 1984), and novelty seeking (Cacioppo & Petty, 1982; Crotts, 1993). Arguably, this would explain the exploratory finding that need for cognition predicted health-related RTB (e.g., unsafe traffic conduct, sexual RTB, and substance use) but not interpersonal RTB (e.g., disobeying parents or teachers), as the former includes more novel or experiential behaviors. Future studies are needed to disentangle need for cognition from related personality traits like openness to experience and novelty seeking.

We hypothesized an association between ADHD symptoms and need for cognition, yet no such association was found. Exploratory analyses revealed that only inattention—and not hyperactivity and impulsivity—was related to a reduced need for cognition. This finding is intuitive, as many inattentive ADHD symptoms are particularly reflective of problems with cognitive demands, whereas hyperactivity/impulsivity is only linked to problems with cognitive demands more indirectly (but see Vahid & Gheysar, 2012). For example, avoidance of tasks that requires a lot of thought, difficulty focusing on details, difficulty remembering things, and keeping overview are all likely to result in a decreased need for cognition (Westbrook & Braver, 2016). Previous work also revealed that need for cognition is associated with the inability to maintain attention during ongoing cognitive tasks (Osberg, 1987). Besides illustrating the value of distinguishing between different symptom clusters of ADHD when studying it in relation to cognitive constructs, these results also impose nuance on the hypothesized association between ADHD symptoms and need for cognition to pertain only to inattention symptoms of ADHD.

Despite several strengths of the current study (e.g., preregistered methodology and large sample size), some limitations warrant consideration. First, we used a continuous measure of ADHD symptoms rather than comparing a group meeting diagnostic ADHD criteria with a typically developing control group. As such, reported effects may not directly translate to a clinical ADHD population. However, treating psychopathology as a dimensional construct finds support with many who argue that a dichotomous approach relies on arbitrary cutoffs and underestimates sample heterogeneity (Coghill & Sonuga-Barke, 2012; Pollak, Poni, Gershy, & Aran, 2017). The latter is especially relevant in ADHD, given its heterogeneous nature (Martel et al., 2010; Sonuga-Barke, 2005; Wåhlstedt et al., 2009). Moreover, a dimensional approach to psychiatry in general is recommended by the RDoC framework by the National Institute of Mental Health (Cuthbert, 2014; Cuthbert & Insel, 2013).

A second and related limitation is the use of a university student sample. As need for cognition generally correlates with intelligence (Fleischhauer et al., 2010), this group is likely to have an above-average need for cognition. Indeed, approximately 81% of the participants scored in the top half of the need for cognition scoring range. Similarly, a large majority of participants used relatively complex decision-making strategies, that is, sequential three-attribute, semi-integrative and integrative strategies. Potentially, the expected mediating effects of need for cognition only become apparent at wider ranges of need for cognition. Similarly, hypothesized effects related to decision-making strategy complexity may become visible only if a sufficient proportion of the sample utilizes simpler decision strategies (e.g., Bexkens et al., 2016; Dekkers et al., 2019). We therefore recommend the use of a more (cognitively) diverse sample in future research.

A final limitation is that the implemented performance-dependent reward may have been insufficiently motivating, considering that the reward was distributed among only five randomly selected participants. Consequently, participants may not have performed to the best of their abilities and were potentially lacking motivation to exert cognitive effort, which could influence the results in many directions. However, this explanation is unlikely because 92% of the participants used one of the three most complex (out of six) decision-making strategy types, which suggests that participants were willing to invest cognitive effort and motivation was adequate.

The current operationalization of decision strategies is similar to earlier work defining decision strategies in terms of their consecutive elementary information processing (EIP) operations (e.g., read, multiply, and compare; Chase, 1978; Johnson & Payne, 1985; Payne et al., 1988). In these studies, the number of EIPs involved was used as a measure for the effort a strategy required. The main difference between the current and the EIP approach is focus, namely, on complexity versus effort—which are related but distinct constructs (Paquette & Kida, 1988).

On a related note, the current study infers strategy assignment by comparing an individuals' observed item–response pattern with those predicted by each decision strategy (Steingroever et al., 2019). An alternative approach would be process tracing, which assesses cognitive processes directly (Beach & Pedersen, 2019; Collier, 2011; George, Bennett, Lynn-Jones, & Miller, 2005) through techniques such as thinking-aloud protocols, tracing of eye and mouse movements, and active information search (Beach & Pedersen, 2019; Ford, Schmitt, Schechtman, Hults, & Doherty, 1989; Payne, Bettman, & Johnson, 1993; Svenson, 1979). Although the latter is recognized for directly rather than indirectly studying the construct(s) of interest, process tracing lacks error modeling and runs an increased risk for inferential biases (Della Porta & Keating, 2008; Einhorn, Kleinmuntz, & Kleinmuntz, 1979). Literature empirically comparing process tracing and outcome-based approaches is scarce, though a combination of the two has been shown to work well in assigning decision strategies to individuals (Riedl, Brandstätter, & Roithmayr, 2008). Future research may look towards combining the current method with process tracing techniques for a more complete overview of decision strategy as a construct.

Future studies are also needed to investigate the potential influence of numeracy, the understanding of and ability to utilize numbers (Peters et al., 2006), which may be relevant for several reasons. First, numeracy is related to EV sensitivity (Jasper, Bhattacharya, Levin, Jones, & Bossard, 2013), which seems especially relevant as the most complex strategy distinguished by the GMT involves comparing EVs. Second, numeracy has been associated with better risk perception (Reyna, Nelson, Han, & Dieckmann, 2009) and to heightened risk sensitivity (Peters, 2012). Third, ADHD has frequently been found associated with reduced numeracy and mathematical skills (Lewandowski, Lovett, Parolin, Gordon, & Codding, 2007; Silva et al., 2015; Van Luit, Kroesbergen, & Naglieri, 2005), and low numeracy mediated the link between ADHD and financial decision-making problems in adults (Bangma et al., 2019). This suggests the involvement of numeracy in the association between ADHD, decision strategy complexity, and RTB.

The current study has some tentative implications for young adults high in ADHD symptoms. First and most obviously, the link between ADHD symptoms and RTB implies that—next to targeting core ADHD symptoms—RTB should always be considered in the assessment and treatment of young adults high in ADHD symptoms. Second, young adults with high levels of inattention demonstrate lower levels of need for cognition. Potentially, these inattentive individuals with low need for cognition may avoid tasks that require cognitive effort, which may impede them on the long term (e.g., in the occupational domain; Adamou et al., 2013). In these cases, treatment could focus on learning strategies to diminish the cognitive effort a certain task requires, such as breaking hard tasks into different pieces, and using cognitive tools such as checklists and agendas to diminish cognitive demands (Boyer, Geurts, Prins, & Van der Oord, 2015; Johnson & Reid, 2011), or applying for a tutor (Azevedo, Cromley, & Seibert, 2004).

ACKNOWLEDGEMENTS

We would like to thank all participants. Furthermore, our gratitude goes to Marieke Jepma for assistance with the Bayesian analyses and to Tinka Beemsterboer for coordinating the test sessions.

CONFLICT OF INTEREST

All authors declare that they have no conflict of interest.

FUNDING INFORMATION

J. N. Z., T. J. D., and H. M. H. are supported by a VICI grant (453-12-005) from the Netherlands Organization for Scientific Research (NWO) and T. J. D. was supported by a grant of the Prins Bernhard Cultuurfonds (40021352). The funding source had no role in the study design, collection, analysis, or interpretation of the data, writing the manuscript, or the decision to submit the paper for publication.

ORCID

Tycho J. Dekkers https://orcid.org/0000-0001-8572-5606

REFERENCES

Adamou, M., Arif, M., Asherson, P., Aw, T. C., Bolea, B., Coghill, D., … Young, S. (2013). Occupational issues of adults with ADHD. *BMC Psychiatry*, *13*(59), 1–7. http://doi.org/10.1186/1471-244X-13-59

Adler, L. A., Shaw, D. M., Spencer, T. J., Newcorn, J. H., Hammerness, P., Sitt, D. J., … Faraone, S. V. (2012). Preliminary examination of the reliability and concurrent validity of the Attention-Deficit/Hyperactivity Disorder Self-Report Scale v1.1 symptom checklist to rate symptoms of attention-deficit/hyperactivity disorder in adolescents. *Journal of Child and Adolescent Psychopharmacology*, *22*(3), 238–244. http://doi.org/10.1089/cap.2011.0062

Alexopoulos, E. C. (2010). Introduction to multivariate regression analysis. *Hippokratia*, *14*, 23–28. http://doi.org/10.2307/2287933

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington DC: American Psychiatric Association. https://doi.org/10.1176/appi.books.9780890425596

Azevedo, R., Cromley, J. G., & Seibert, D. (2004). Does adaptive scaffolding facilitate students' ability to regulate their learning with hypermedia? *Contemporary Educational Psychology*, *29*(3), 344–370. http://doi.org/10.1016/j.cedpsych.2003.09.002

Bangma, D. F., Koerts, J., Fuermaier, A., Mette, C., Zimmermann, M., Toussaint, A. K., … Tucha, O. (2019). Financial decision-making in adults with ADHD. *Neuropsychology*, *33*, 1065–1077. https://doi.org/10.1037/neu0000571

Beach, D., & Pedersen, R. B. (2019). *Process-tracing methods: Foundations and guidelines*. Ann Arbor, Michigan: University of Michigan Press. https://doi.org/10.3998/mpub.10072208

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition*, *50*(1–3), 7–15. http://doi.org/10.1016/0010-0277(94)90018-3

Bender, R., & Lange, S. (2001). Adjusting for multiple testing—When and how? *Journal of Clinical Epidemiology*, *54*(4), 343–349. http://doi.org/10.1016/S0895-4356(00)00314-0

Bexkens, A., Jansen, B. R. J., Van der Molen, M. W., & Huizenga, H. M. (2016). Cool decision-making in adolescents with behavior disorder and/or mild-to-borderline intellectual disability. *Journal of Abnormal Child Psychology*, *44*(2), 357–367. http://doi.org/10.1007/s10802-015-9996-8

Bhat, H., & Kumar, N. (2010). *On the derivation of the Bayesian information criterion*. Berkeley: School of natural sciences, University of California.

Blais, A.-R., & Weber, E. U. (2006). A domain-specific risk-taking (DOSPERT) scale for adult populations. *Judgment and Decision Making*, *1*(1), 33–47.

Boyer, B. E., Geurts, H. M., Prins, P. J. M., & Van der Oord, S. (2015). Two novel CBTs for adolescents with ADHD: The value of planning skills.

European Child and Adolescent Psychiatry, *24*(9), 1075–1090. http://doi.org/10.1007/s00787-014-0661-5

Caci, H., Bouchez, J., & Baylé, F. J. (2009). Inattentive symptoms of ADHD are related to evening orientation. *Journal of Attention Disorders*, *13*(1), 36–41. http://doi.org/10.1177/1087054708320439

Cacioppo, J. T., & Petty, R. E. (1982). The need for cognition. *Journal of Personality and Social Psychology*, *42*(1), 116–131. http://doi.org/10.1037/0022-3514.42.1.116

Cacioppo, J. T., Petty, R. E., & Feng Kao, C. (1984). The efficient assessment of need for cognition. *Journal of Personality Assessment*, *48*(3), 306–307. http://doi.org/10.1207/s15327752jpa4803_13

Cacioppo, J. T.,Petty, R. E.,Feinstein, J. A., &Jarvis, W. B. G.(1996). Dispositional differences in cognitive motivation: The life and times of individuals varying in need for cognition. *Psychological bulletin*, *119*(2), 197-253.

Chase, W. G. (1978). Elementary information processes. In W. K. Estes (Ed.), *Handbook of learning & cognitive processes: V. Human information* (pp. 19–90). Mahwah, New Jersey: Lawrence Erlbaum.

Chatterjee, S., Heath, T. B., Milberg, S. J., & France, K. R. (2000). The differential processing of price in gains and losses: The effects of frame and need for cognition. *Journal of Behavioral Decision Making*, *13*(1), 61–75. http://doi.org/10.1002/(SICI)1099-0771(200001/03)13:1<61::AID-BDM343>3.0.CO;2-J

Coghill, D., & Sonuga-Barke, E. J. S. (2012). Annual research review: Categories versus dimensions in the classification and conceptualisation of child and adolescent mental disorders-Implications of recent empirical study. *Journal of Child Psychology and Psychiatry*, *53*(5), 469–489. http://doi.org/10.1111/j.1469-7610.2011.02511.x

Collier, D. (2011). Understanding process tracing. *PS - Political Science and Politics*, *44*(4), 823–830. http://doi.org/10.1017/S1049096511001429

Crotts, J. C. (1993). Personality correlates of the novelty seeking drive. *Journal of Hospitality & Leisure Marketing*, *1*(3), 7–29. http://doi.org/10.1300/j150v01n03_03

Curseu, P. (2006). Need for cognition and rationality in decision making. *Studia Psychologica*, *48*(2), 141–156.

Cuthbert, B. N. (2014). The RDoC framework: Facilitating transition from ICD/DSM to dimensional approaches that integrate neuroscience and psychopathology. *World Psychiatry*, *13*(1), 28–35. http://doi.org/10.1002/wps.20087

Cuthbert, B. N., & Insel, T. R. (2013). Toward the future of psychiatric diagnosis: The seven pillars of RDoC. *BMC Medicine*, *11*(1), 126. http://doi.org/10.1186/1741-7015-11-126

Dekkers, T. J., Agelink van Rentergem, J. A., Huizenga, H. M., Raber, H., Shoham, R., Popma, A., & Pollak, Y. (2018). Decision-making deficits in ADHD are not related to risk seeking but to suboptimal decision-making: Meta-analytical and novel experimental evidence. *Journal of Attention Disorders*. http://doi.org/10.1177/1087054718815572

Dekkers, T. J., Huizenga, H. M., Bult, J., Popma, A., & Boyer, B. E. (n.d.). The influence of parental knowledge on ADHD-related problems: Elucidating risk-taking behavior and homework problems in adolescents.

Dekkers, T. J., Huizenga, H. M., Popma, A., Bexkens, A., Zadelaar, J. N., & Jansen, B. R. J. (2019). Decision-making deficits in adolescent boys with and without attention-deficit/hyperactivity disorder (ADHD): An experimental assessment of associated mechanisms. *Journal of Abnormal Child Psychology*. http://doi.org/10.1007/s10802-019-00613-7

Dekkers, T. J., Popma, A., Agelink van Rentergem, J. A., Bexkens, A., & Huizenga, H. M. (2016). Risky decision making in attention-deficit/-hyperactivity disorder: A meta-regression analysis. *Clinical Psychology Review*, *45*, 1–16. http://doi.org/10.1016/j.cpr.2016.03.001

Della Porta, D., & Keating, M. (2008). *Approaches and methodologies in the social sciences: A pluralist perspective*. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511801938

DeStefano, D., & LeFevre, J. A. (2004). The role of working memory in mental arithmetic. *European Journal of Cognitive Psychology*, *16*(3), 353–386. http://doi.org/10.1080/09541440244000328

Dietrich, C. (2010). Decision making: Factors that influence decision making, heuristics used, and decision outcomes. *Inquiries Journal*, *2*(2), 2–3.

Dovis, S., Van der Oord, S., Wiers, R. W., & Prins, P. J. M. (2012). Can motivation normalize working memory and task persistence in children with attention-deficit/hyperactivity disorder? The effects of money and computer-gaming. *Journal of Abnormal Child Psychology*, *40*(5), 669–681. http://doi.org/10.1007/s10802-011-9601-8

DuPaul, G. J., Power, T., Anastopoulos, A., & Reid, R. (1998). *ADHD rating scale-IV. Checklists, norms and clinical interpretation*. New York: Guilford Press.

DuPaul, G. J., Weyandt, L. L., O'Dell, S. M., & Varejao, M. (2009). College students with ADHD: Current status and future directions. *Journal of Attention Disorders*, *13*(3), 234–250. http://doi.org/10.1177/1087054709340650

Egeland, J., Johansen, S. N., & Ueland, T. (2010). Do low-effort learning strategies mediate impaired memory in ADHD? *Journal of Learning Disabilities*, *43*(5), 430–440. http://doi.org/10.1177/0022219409355473

Einhorn, H. J., Kleinmuntz, D. N., & Kleinmuntz, B. (1979). Linear regression and process-tracing models of judgment. *Psychological Review*, *86*(5), 465–485. http://doi.org/10.1037/0033-295X.86.5.465

Field, A. P. (2013). *Discovering statistics using IBM SPSS statistics* (4th ed.). Los Angeles: Sage.

Figner, B., Mackinlay, R. J., Wilkening, F., & Weber, E. U. (2009). Affective and deliberative processes in risky choice: Age differences in risk taking in the Columbia card task. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *35*(3), 709–730. http://doi.org/10.1037/a0014983

Figner, B., & Weber, E. U. (2011). Who takes risks when and why? Determinants of risk taking. *Current Directions in Psychological Science*, *20*(4), 211–216. http://doi.org/10.1177/0963721411415790

Fleischhauer, M., Enge, S., Brocke, B., Ullrich, J., Strobel, A., & Strobel, A. (2010). Same or different? Clarifying the relationship of need for cognition to personality and intelligence. *Personality and Social Psychology Bulletin*, *36*(1), 82–96. http://doi.org/10.1177/0146167209351886

Ford, J. K., Schmitt, N., Schechtman, S. L., Hults, B. M., & Doherty, M. L. (1989). Process tracing methods: Contributions, problems, and neglected research questions. *Organizational Behavior and Human Decision Processes*, *43*(1), 75–117. http://doi.org/10.1016/0749-5978(89)90059-9

Fritz, M. S., & MacKinnon, D. P. (2007). Required sample size to detect the mediated effect. *Psychological Science*, *18*(3), 233–239. http://doi.org/10.1111/j.1467-9280.2007.01882.x

George, A. L., Bennett, A., Lynn-Jones, S. M., & Miller, S. E. (2005). *Case studies and theory development in the social sciences*. Cambridge, Massachusetts: MIT Press.

Gigerenzer, G., & Gaissmaier, W. (2011). Heuristic decision making. *Annual Review of Psychology*, *62*(1), 451–482. http://doi.org/10.1146/annurev-psych-120709-145346

Gigerenzer, G., & Goldstein, D. G. (1999). Betting on one good reason: The take the best heuristic. In *Simple heuristics that make us smart* (pp. 75–95). Oxford: Oxford University Press.

Graefe, A., & Armstrong, J. S. (2012). Predicting elections from the most important issue: A test of the take-the-best heuristic. *Journal of Behavioral Decision Making*, *25*(1), 41–48. http://doi.org/10.1002/bdm.710

Hanoch, Y., Johnson, J. G., & Wilke, A. (2006). Domain specificity in experimental measures and participant recruitment: An application to risk-taking behavior. *Psychological Science*, *17*(4), 300–304. http://doi.org/10.1111/j.1467-9280.2006.01702.x

Hardman, D., & Hardman, D. K. (2009). *Judgment and decision making: Psychological perspectives (Vol. 11)*. Hoboken, New Jersey: John Wiley & Sons, Ltd.

Harman, J. L. (2011). Individual differences in need for cognition and decision making in the Iowa gambling task. *Personality and Individual Differences*, *51*(2), 112–116. http://doi.org/10.1016/j.paid.2011.03.021

Hauser, J. R. (2014). Consideration-set heuristics. *Journal of Business Research*, *67*(8), 1688–1699. http://doi.org/10.1016/j.jbusres.2014.02.015

Hauser, J. R., Ding, M., & Gaskin, S. P. (2009). Non-compensatory (and compensatory) models of consideration-set decisions. *Proceedings of the Sawtooth Software Conference*, *14*, 207–232.

Hayes, A. (2018). *Introduction to mediation, moderation, and conditional process analysis (second)*. New York: Guilford Press.

Hesse, M. (2013). The ASRS-6 has two latent factors: Attention deficit and hyperactivity. *Journal of Attention Disorders*, *17*(3), 203–207. http://doi.org/10.1177/1087054711430330

Huizenga, H. M., Crone, E. A., & Jansen, B. R. J. (2007). Decision-making in healthy children, adolescents and adults explained by the use of increasingly complex proportional reasoning rules. *Developmental Science*, *10*(6), 814–825. http://doi.org/10.1111/j.1467-7687.2007.00621.x

Jansen, B. R. J., & Van der Maas, H. L. J. (1997). Statistical test of the rule assessment methodology by latent class analysis. *Developmental Review*, *17*(3), 321–357. http://doi.org/10.1006/DREV.1997.0437

Jansen, B. R. J., & Van der Maas, H. L. J. (2002). The development of children's rule use on the balance scale task. *Journal of Experimental Child Psychology*, *81*(4), 383–416. http://doi.org/10.1006/jecp.2002.2664

Jansen, B. R. J., van Duijvenvoorde, A. C. K., & Huizenga, H. M. (2012). Development of decision making: Sequential versus integrative rules. *Journal of Experimental Child Psychology*, *111*(1), 87–100. http://doi.org/10.1016/j.jecp.2011.07.006

Jasper, J. D., Bhattacharya, C., Levin, I. P., Jones, L., & Bossard, E. (2013). Numeracy as a predictor of adaptive risky decision making. *Journal of Behavioral Decision Making*, *26*(2), 164–173. http://doi.org/10.1002/bdm.1748

Johnson, E. J., & Payne, J. W. (1985). Effort and accuracy in choice. *Management Science*, *31*(4), 395–414. http://doi.org/10.1287/mnsc.31.4.395

Johnson, J., & Reid, R. (2011). Overcoming executive function deficits with students with ADHD. *Theory into Practice*, *50*(1), 61–67. http://doi.org/10.1080/00405841.2010.534942

Kasper, L. J., Alderson, R. M., & Hudec, K. L. (2012). Moderators of working memory deficits in children with attention-deficit/hyperactivity disorder (ADHD): A meta-analytic review. *Clinical Psychology Review*, *32*(7), 605–617. http://doi.org/10.1016/J.CPR.2012.07.001

Kessler, R. C., Adler, L., Ames, M., Demler, O., Faraone, S., Hiripi, E. V., … Ustun, T. B. (2005). The World Health Organization adult ADHD Self-Report Scale (ASRS): A short screening scale for use in the general population. *Psychological Medicine*, *35*(2), 245–256. http://doi.org/10.1017/S0033291704002892

Kim, J.-H., Lee, E.-H., & Joung, Y.-S. (2013). The WHO adult ADHD Self-Report Scale: Reliability and validity of the Korean version. *Psychiatry Investigation*, *10*(1), 41–46. http://doi.org/10.4306/pi.2013.10.1.41

Kofler, M. J., Raiker, J. S., Sarver, D. E., Wells, E. L., & Soto, E. F. (2016). Is hyperactivity ubiquitous in ADHD or dependent on environmental demands? Evidence from meta-analysis. *Clinical Psychology Review*, *46*, 12–24. http://doi.org/10.1016/J.CPR.2016.04.004

Kool, W., McGuire, J. T., Rosen, Z. B., & Botvinick, M. M. (2010). Decision making and the avoidance of cognitive demand. *Journal of Experimental Psychology: General*, *139*(4), 665–682. http://doi.org/10.1037/a0020198

Lejuez, C. W., Read, J. P., Kahler, C. W., Richards, J. B., Ramsey, S. E., Stuart, G. L., … Brown, R. A. (2002). Evaluation of a behavioral measure of risk taking: The balloon analogue risk task (BART). *Journal of Experimental Psychology: Applied*, *8*(2), 75–84. http://doi.org/10.1037//1076-898X.8.2.75

Lewandowski, L. J., Lovett, B. J., Parolin, R., Gordon, M., & Codding, R. S. (2007). Extended time accommodations and the mathematics performance of students with and without ADHD. *Journal of Psychoeducational Assessment*, *25*(1), 17–28. http://doi.org/10.1177/0734282906291961

Leys, C., Ley, C., Klein, O., Bernard, P., & Licata, L. (2013). Detecting outliers: Do not use standard deviation around the mean, use absolute deviation around the median. *Journal of Experimental Social Psychology*, *49*(4), 764–766. http://doi.org/10.1016/j.jesp.2013.03.013

Lins de Holanda Coelho, G., Hanel, P., & Wolf, L. (2018). The very efficient assessment of need for cognition: Developing a six-item version. *Assessment*, *1*, 1-16. http://doi.org/10.1177/1073191118793208

Luman, M., Oosterlaan, J., & Sergeant, J. A. (2005). The impact of reinforcement contingencies on AD/HD: A review and theoretical appraisal. *Clinical Psychology Review*, *25*(2), 183–213. http://doi.org/10.1016/j.cpr.2004.11.001

Mäntylä, T., Still, J., Gullberg, S., & Del Missier, F. (2012). Decision making in adults with ADHD. *Journal of Attention Disorders*, *16*(2), 164–173. http://doi.org/10.1177/1087054709360494

Martel, M. M., Goth-Owens, T., Martinez-Torteya, C., & Nigg, J. T. (2010). A person-centered personality approach to heterogeneity in attention-deficit/hyperactivity disorder (ADHD). *Journal of Abnormal Psychology*, *119*(1), 186–196. http://doi.org/10.1037/a0017511

Masunami, T., Okazaki, S., & Maekawa, H. (2009). Decision-making patterns and sensitivity to reward and punishment in children with attention-deficit hyperactivity disorder. *International Journal of Psychophysiology*, *72*(3), 283–288. http://doi.org/10.1016/j.ijpsycho.2009.01.007

Maxwell, S. E., Cole, D. A., & Mitchell, M. A. (2011). Bias in cross-sectional analyses of longitudinal mediation: Partial and complete mediation under an autoregressive model. *Multivariate Behavioral Research*, *46*(5), 816–841. http://doi.org/10.1080/00273171.2011.606716

Montgomery, H., & Adelbratt, T. (1982). Gambling decisions and information about expected value. *Organizational Behavior and Human Performance*, *29*(1), 39–57. http://doi.org/10.1016/0030-5073(82)90241-0

Mowinckel, A. M., Pedersen, M. L., Eilertsen, E., & Biele, G. (2015). A meta-analysis of decision-making and attention in adults with ADHD. *Journal of Attention Disorders*, *19*(5), 355–367. http://doi.org/10.1177/1087054714558872

Muthén, L., & Muthén, B. (2012). Mplus: Statistical analysis with latent variables—User's guide.

Muthén, L., & Muthén, B. (2017). *Mplus user's guide* (8th ed.). Los Angeles, CA: Muthen & Muthen.

Nair, K. U., & Ramnarayan, S. (2000). Individual differences in need for cognition and complex problem solving. *Journal of Research in Personality*, *34*(3), 305–328. http://doi.org/10.1006/JRPE.1999.2274

Newell, B. R., Lagnado, D. A., & Shanks, D. R. (2007). Challenging the role of implicit processes in probabilistic category learning. *Psychonomic Bulletin & Review*, *14*(3), 505–511. http://doi.org/10.3758/BF03194098

Nigg, J. T. (2013). Attention-deficit/hyperactivity disorder and adverse health outcomes. *Clinical Psychology Review*, *33*(2), 215–228. http://doi.org/10.1016/J.CPR.2012.11.005

Olson, K., Camp, C., & Fuller, D. (1984). Curiosity and need for cognition. *Psychological Reports*, *54*(1), 71–74. http://doi.org/10.2466/pr0.1984.54.1.71

Osberg, T. M. (1987). The convergent and discriminant validity of the need for cognition scale. *Journal of Personality Assessment*, *51*(3), 441–450. http://doi.org/10.1207/s15327752jpa5103_11

Paquette, L., & Kida, T. (1988). The effect of decision strategy and task complexity on decision performance. *Organizational Behavior and*

Human Decision Processes, *41*(1), 128–142. http://doi.org/10.1016/0749-5978(88)90051-9

Pat-Horenczyk, R., Peled, O., Miron, T., Brom, D., Villa, Y., & Chemtob, C. M. (2007). Risk-taking behaviors among Israeli adolescents exposed to recurrent terrorism: Provoking danger under continuous threat? *American Journal of Psychiatry*, *164*(1), 66–72. http://doi.org/10.1176/appi.ajp.164.1.66

Patros, C. H. G., Alderson, R. M., Kasper, L. J., Tarle, S. J., Lea, S. E., & Hudec, K. L. (2016). Choice-impulsivity in children and adolescents with attention-deficit/hyperactivity disorder (ADHD): A meta-analytic review. *Clinical Psychology Review*, *43*, 162–174. http://doi.org/10.1016/j.cpr.2015.11.001

Payne, J. W. (1976). Task complexity and contingent processing in decision making: An information search and protocol analysis. *Organizational Behavior and Human Performance*, *16*(2), 366–387. http://doi.org/10.1016/0030-5073(76)90022-2

Payne, J. W., Bettman, J. R., & Johnson, E. J. (1988). Adaptive strategy selection in decision making. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *14*(3), 534–552. http://doi.org/10.1037/0278-7393.14.3.534

Payne, J. W., Bettman, J. R., & Johnson, E. J. (1993). *The adaptive decision maker*. Cambridge: Cambridge University Press.

Payne, J. W., Bettman, J. R., Johnson, E. J., & Luce, M. F. (1995). An information processing perspective on choice. *Psychology of Learning and Motivation - Advances in Research and Theory*, *32*, 137–175. http://doi.org/10.1016/S0079-7421(08)60309-6

Peters, E. (2012). Beyond comprehension: The role of numeracy in judgments and decisions. *Current Directions in Psychological Science*, *21*(1), 31–35. http://doi.org/10.1177/0963721411429960

Peters, E., Vastfjall, D., Slovic, P., Mertz, C. K., Mazzocco, K., & Dickert, S. (2006). Numeracy and decision making. *Psychological Science*, *17*(5), 407–413. https://doi.org/10.1111/j.1467-9280.2006.01720.x

Pollak, Y., & Aran, A. (n.d.), ADorTI (personal communication)

Pollak, Y., Dekkers, T. J., Shoham, R., & Huizenga, H. M. (2019). Risk-taking behavior in attention deficit/hyperactivity disorder (ADHD): A review of potential underlying mechanisms and of interventions. *Current Psychiatry Reports*, *21*(5), 33. http://doi.org/10.1007/s11920-019-1019-y

Pollak, Y., Poni, B., Gershy, N., & Aran, A. (2017). The role of parental monitoring in mediating the link between adolescent ADHD symptoms and risk-taking behavior. *Journal of Attention Disorders*, 108705471772587. http://doi.org/10.1177/1087054717725875

Reuter, M., Kirsch, P., & Hennig, J. (2006). Inferring candidate genes for attention deficit hyperactivity disorder (ADHD) assessed by the World Health Organization Adult ADHD Self-Report Scale (ASRS). *Journal of Neural Transmission*, *113*(7), 929–938. http://doi.org/10.1007/s00702-005-0366-5

Reyna, V. F., Nelson, W. L., Han, P. K., & Dieckmann, N. F. (2009). How numeracy influences risk comprehension and medical decision making. *Psychological Bulletin*, *135*(6), 943–973. http://doi.org/10.1037/a0017327

Riedl, R., Brandstätter, E., & Roithmayr, F. (2008). Identifying decision strategies: A process- and outcome-based classification method. *Behavior research methods*. *40*(3), 795–807. http://doi.org/10.3758/BRM.40.3.795

Robb, J. A., Sibley, M. H., Pelham, W. E., Michael Foster, E., Molina, B. S. G., Gnagy, E. M., & Kuriyan, A. B. (2011). The estimated annual cost of ADHD to the US education system. *School Mental Health*, *3*(3), 169–177. http://doi.org/10.1007/s12310-011-9057-6

Rolls, E. T., McCabe, C., & Redoute, J. (2008). Expected value, reward outcome, and temporal difference error representations in a probabilistic decision task. *Cerebral Cortex (New York, N.Y. : 1991)*, *18*(3), 652–663. http://doi.org/10.1093/cercor/bhm097

Rothman, K. J. (1990). No adjustments are needed for multiple comparisons. *Epidemiology*, *1*(1), 43–46. https://doi.org/10.1097/00001648-199001000-00010

Royston, P., Altman, D. G., & Sauerbrei, W. (2006). Dichotomizing continuous predictors in multiple regression: A bad idea. *Statistics in Medicine*, *25*(1), 127–141. http://doi.org/10.1002/sim.2331

Ruiter, R. A. C., Verplanken, B., De Cremer, D., & Kok, G. (2004). Danger and fear control in response to fear appeals: The role of need for cognition. *Basic and Applied Social Psychology*, *26*(1), 13–24. http://doi.org/10.1207/s15324834basp2601_2

Sadowski, C. J., & Cogburn, H. E. (1997). Need for cognition in the Big-Five factor structure. *Journal of Psychology: Interdisciplinary and Applied*, *131*(3), 307–312. http://doi.org/10.1080/00223989709603517

Schmid, K. L., Rivers, S. E., Latimer, A. E., & Salovey, P. (2008). Targeting or tailoring? Maximizing resources to create effective health communications. *Marketing Health Services*, *28*(1), 32–37.

Schwarz, G. (1978). Estimating the dimension of a model. *The Annals of Statistics*, *6*(2), 461–464. http://doi.org/10.1214/aos/1176344136

Sergeant, J. A. (2005). Modeling attention-deficit/hyperactivity disorder: A critical appraisal of the cognitive-energetic model. *Biological Psychiatry*, *57*(11), 1248–1255. http://doi.org/10.1016/J.BIOPSYCH.2004.09.010

Shoham, R., Sonuga-Barke, E. J. S., Aloni, H., Yaniv, I., & Pollak, Y. (2016). ADHD-associated risk taking is linked to exaggerated views of the benefits of positive outcomes. *Scientific Reports*, *6*(34833), 1–8. http://doi.org/10.1038/srep34833

Siegler, R. S., Strauss, S., & Levin, I. (1981). Developmental sequences within and between concepts. *Monographs of the Society for Research in Child Development*, *46*(2), 1–84. http://doi.org/10.2307/1165995

Silva, D., Colvin, L., Glauert, R., Stanley, F., Srinivas Jois, R., & Bower, C. (2015). Literacy and numeracy underachievement in boys and girls with ADHD. *Journal of Attention Disorders*. 1-11. http://doi.org/10.1177/1087054715613438

Simon, A. F., Fagley, N. S., & Halleran, J. G. (2004). Decision framing: Moderating effects of individual differences and cognitive processing. *Journal of Behavioral Decision Making*, *17*(2), 77–93. http://doi.org/10.1002/bdm.463

Smith, S., & Levin, I. (1996). Need for cognition and choice framing effects. *Journal of Behavioral Decision Making*, *9*(4), 283–290. http://doi.org/10.1002/(SICI)1099-0771(199612)9:4<283::AID-BDM241>3.0.CO;2-7

Sonuga-Barke, E. J. S. (2005). Causal models of attention-deficit/-hyperactivity disorder: From common simple deficits to multiple developmental pathways. *Biological Psychiatry*, *57*(11), 1231–1238. http://doi.org/10.1016/j.biopsych.2004.09.008

Spiegel, T., & Pollak, Y. (2019). Attention deficit/hyperactivity disorder and increased engagement in sexual risk-taking behavior: The role of benefit perception. *Frontiers in Psychology*, *10*, 1-8, 1043. http://doi.org/10.3389/fpsyg.2019.01043

Steingroever, H., Jepma, M., Lee, M. D., Jansen, B. R. J., & Huizenga, H. M. (2019). Detecting strategies in developmental psychology. *Computational Brain & Behavior*, *2*(2), 128–140. http://doi.org/10.1007/s42113-019-0024-x

Steinhart, Y., & Wyer, R. S. (2009). Motivational correlates of need for cognition. *European Journal of Social Psychology*, *39*(4), 608–621. http://doi.org/10.1002/ejsp.565

Stewart, N. (2009). Decision by sampling: The role of the decision environment in risky choice. *Quarterly Journal of Experimental Psychology*, *62*(6), 1041–1062. http://doi.org/10.1080/17470210902747112

Streiner, D. L., & Norman, G. R. (2011). Correction for multiple testing: Is there a resolution? *Chest*, *140*(1), 16–18. http://doi.org/10.1378/CHEST.11-0523

Svenson, O. (1979). Process descriptions of decision making. *Organizational Behavior and Human Performance*, *23*(1), 86–112. http://doi.org/10.1016/0030-5073(79)90048-5

Thomas, R., Sanders, S., Doust, J., Beller, E., & Glasziou, P. (2015). Prevalence of attention-deficit/hyperactivity disorder: A systematic review and meta-analysis. *Pediatrics*, *135*(4), e994–e1001. http://doi.org/10.1542/PEDS.2014-3482

Tuten, T. L., & Bosnjak, M. (2006). Understanding differences in web usage: The role of need for cognition and the five factor model of personality. *Social Behavior and Personality: An International Journal*, *29*(4), 391–398. http://doi.org/10.2224/sbp.2001.29.4.391

Vahid, N., & Gheysar, M. (2012). The relationship between impulsive and reflective problem solving behavior. *Zahedan Journal of Research in Medical Sciences*, *14*(1), 76–81.

van Duijvenvoorde, A. C. K., Figner, B., Weeda, W. D., Van der Molen, M. W., Jansen, B. R. J., & Huizenga, H. M. (2016). Neural mechanisms underlying compensatory and noncompensatory strategies in risky choice. *Journal of Cognitive Neuroscience*, *28*(9), 1358–1373. http://doi.org/10.1162/jocn_a_00975

Van Luit, J. E. H., Kroesbergen, E. H., & Naglieri, J. A. (2005). Utility of the PASS theory and cognitive assessment system for Dutch children with and without ADHD. *Journal of Learning Disabilities*, *38*(5), 434–439. http://doi.org/10.1177/00222194050380050601

Vaurio, R. G., Simmonds, D. J., & Mostofsky, S. H. (2009). Increased intra-individual reaction time variability in attention-deficit/hyperactivity disorder across response inhibition tasks with different cognitive demands. *Neuropsychologia*, *47*(12), 2389–2396. http://doi.org/10.1016/j.neuropsychologia.2009.01.022

Verplanken, B. (1993). Need for cognition and external information search: Responses to time pressure during decision-making. *Journal of Research in Personality*, *27*(3), 238–252. http://doi.org/10.1006/JRPE.1993.1017

Wåhlstedt, C., Thorell, L. B., & Bohlin, G. (2009). Heterogeneity in ADHD: Neuropsychological pathways, comorbidity and symptom domains. *Journal of Abnormal Child Psychology*, *37*(4), 551–564. http://doi.org/10.1007/s10802-008-9286-9

Westbrook, A., & Braver, T. S. (2016). Dopamine does double duty in motivating cognitive effort. *Neuron*, *89*(4), 695–710. http://doi.org/10.1016/j.neuron.2015.12.029

Willcutt, E. G. (2012). The prevalence of DSM-IV attention-deficit/-hyperactivity disorder: A meta-analytic review. *Neurotherapeutics*, *9*(3), 490–499. http://doi.org/10.1007/s13311-012-0135-8

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the executive function theory of attention-deficit/-hyperactivity disorder: A meta-analytic review. *Biological Psychiatry*, *57*(11), 1336–1346. http://doi.org/10.1016/j.biopsych.2005.02.006

Williams-Piehota, P., Schneider, T. R., Pizarro, J., Mowad, L., & Salovey, P. (2003). Matching health messages to information-processing styles: Need for cognition and mammography utilization. *Health Communication*, *15*(4), 375–392. http://doi.org/10.1207/S15327027HC1504_01

Zhao, X., Page, T. F., Altszuler, A. R., Pelham, W. E., Kipp, H., Gnagy, E. M., … Pelham, W. E. (2019). Family burden of raising a child with ADHD. *Journal of Abnormal Child Psychology*, *47*, 1–12. http://doi.org/10.1007/s10802-019-00518-5

Ziglari, L. (2017). Interpreting multiple regression results: β weights and structure coefficients. *General Linear Model Journal*, *43*(2), 13–22. http://doi.org/10.31523/glmj.043002.002

AUTHOR BIOGRAPHIES

Jacqueline Zadelaar is a PhD candidate at the University of Amsterdam; her research revolves around decision making with a focus on the modelling of behavioral or combined behavioral and neuroimaging data.

Tycho Dekkers is a PhD candidate at the University of Amsterdam; his dissertation focuses on risk taking and ADHD using a decision theory-based framework. He is also a licensed healthcare psychologist, working with children and adolescents with behavioral disorders at De Bascule and Amsterdam UMC.

Hilde Huizenga is a professor in developmental psychology at the University of Amsterdam and specialized in decision making across the life span as well as modeling of behavioral and brain indices of (a)typical development.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

How to cite this article: Zadelaar JN, Dekkers TJ, Huizenga HM. The association between risky decision making and attention-deficit/hyperactivity disorder symptoms: A preregistered assessment of need for cognition as underlying mechanism. *J Behav Dec Making*. 2020;1–14. https://doi.org/10.1002/bdm.2177