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Risk taking and adult attention deficit/hyperactivity disorder: A gap between real life behavior and experimental decision making

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ABSTRACT

Adults with attention deficit/hyperactivity disorder (ADHD) are prone to suboptimal decision making and risk taking. The aim of this study was to test performance on a theoretically-based probabilistic decision making task in well-characterized adults with and without ADHD, and examine the relation between experimental risk taking and history of real-life risk-taking behavior, defined as cigarette, alcohol, and street drug use. University students with and without ADHD completed a modified version of the Cambridge Gambling Test, in which they had to choose between alternatives varied by level of risk, and reported their history of substance use. Both groups showed similar patterns of risk taking on the experimental decision making task, suggesting that ADHD is not linked to low sensitivity to risk. Past and present substance use was more prevalent in adults with ADHD. These finding question the validity of experimental probabilistic decision making task as a valid model for ADHD-related risk-taking behavior.

1. Introduction

Attention deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder, characterized by a persistent pattern of inattentive, hyperactive, and impulsive behavior, interfering with educational, social, occupational, and health-related functioning (American Psychiatric Association, 2013; Faraone et al., 2015; Nigg, 2013). Adolescents and adults diagnosed with ADHD engage in risky behaviors more often than their control counterparts. Such behaviors include smoking, alcohol, and drug abuse, criminal behavior, dangerous driving, gambling, and unprotected sex (Breyer et al., 2009; Charach et al., 2011; Dhami and Mandel, 2012; Fuermaier et al., 2017; Lee et al., 2011; Molina and Pelham, 2014; Sarver et al., 2014; Shoham et al., 2016).

The link between ADHD and risk-taking behavior, including substance abuse, is a major public health issue. About 30% of adults presenting with substance use disorder (SUD) have a concomitant ADHD, and approximately 20 to 40% of adults with ADHD have histories of SUD (Bukstein, 2012). Early implementation of preventive interventions aimed to reduce risk-taking behavior in adolescents with ADHD is necessary. It can have remarkable implications for patients, families, and health system expenses.

Risk taking is an engagement in behaviors that are associated with some probability of hazardous results (Boyer, 2006). Relying on the probabilistic nature of risk-taking behavior, some researchers have adopted the strategy of assessing performance on laboratory-based probabilistic decision-making tasks (Schonberg et al., 2011) in order to provide a model of actual risk-taking behavior while controlling for key variables of interest.

A popular laboratory procedure used for studying risk taking in ADHD involves gambling tasks, where subjects are asked to choose between safe and risky alternatives. Recent review (Groen et al., 2013) and meta-analyses (Dekkers et al., 2016; Mowinckel et al., 2015) found only a mild-to-moderate difference between ADHD and control children. “Only a minority of studies in adults (27%) reported greater risky performance in individuals with ADHD when compared to normal controls” (Groen et al., 2013, p. 13). Some studies have even shown less risk taking among individuals with ADHD (Humphreys et al., 2016; Kroyzer et al., 2014; Pollak and Shoham, 2015).

Decision-making tasks are often analyzed using a decision theory perspective. According to the expected utility framework, the expected value of a risky alternative comprises its subjective potential payoff weighted by its probability. A rational decision maker is supposed to opt for the alternative with the highest expected value (Schonberg et al., 2011).

One way to probe risk taking in the laboratory is by using pricing tasks. On these tasks, participants are asked how much money (points) they wish to invest for the possibility to participate in a gamble. One

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such task is the Cambridge Gambling Test (CGT, Rogers et al., 1999), in which subjects are given explicit probabilistic information (e.g., 20% chance that a token was hidden inside a blue box, 80% chance it was hidden inside a red box). The subjects are then asked to guess in which box (red or blue) the token is placed, and to determine the magnitude of bet they are willing to risk, given the probabilities.

The CGT separately taps several processes that are involved in decision making: *quality of gamble* (the percent of trials in which the participant chooses the gamble with the higher probability to win), *sum of bet* (the total number of points gambled indicating the overall tendency to take risks or the sensitivity to risk), *risk adjustment* (the ability to adjust choices to the probability of winning), *deliberation time* (the time it takes to make a decision), and *delay aversion* (the tendency to choose bets' options that were presented earlier to the subject).

From an expected utility perspective, the first three measures indicate the rationality of the decision and the sensitivity to risk. Quality of gamble shows whether subjects understand the concept of probability and trust the probabilities presented by the experimenter. If a subject predicts that the token is inside the box with the 10% probability rather than the one with the 90% probability, it is irrational and reflects either misunderstanding and confusion or distrust. Once the subject understands the task and believes the instructions are true, they should always choose the alternative with a higher probability of winning. Risk taking reflects the magnitude of risk the subject is ready to take for the relevant probabilities. Risk adjustment indicates the participant's ability to distinguish between different levels of risk and adjust their betting accordingly. Importantly, as the chances to win in the CGT are always higher than the chances to lose, the higher the bet is, the higher is its expected value (e.g., when the chance to win is 70% and to lose – 30%, the expected value of betting 100 points is $.7 \times 100 - .3 \times 100 = 40$, whereas the expected value of betting 10 points is $.7 \times 10 - .3 \times 10 = 4$). Consequently, the best strategy is to constantly bet on the maximal sum. Therefore, if a subject adheres to the best strategy, his risk adjustment is poor (but rational).

In the current study, we focused on the CGT, as its complex structure and theoretically-based indices enable the examination of specific hypotheses regarding ADHD-related decision making.

Data regarding how individuals with ADHD perform the CGT has been presented, to the best of our knowledge, in six papers. In this short review, we will focus on the three risky decision-making measures mentioned above. The first of the six studies examined adults with and without ADHD on the CGT, reporting that the two diagnostic groups performed equivalently on all measures (McLean et al., 2004). DeVito et al. (2008) reported that children with and without ADHD showed similar betting magnitude, but children with ADHD demonstrated poorer quality of gamble and less steep risk adjustment. In the third study (Coghill et al., 2014), the authors found that quality of gamble and risk adjustment scores loaded on one factor, which was impaired in the ADHD group. The authors did not report on the sum of bet. A recent study found that children with and without ADHD made similar bets, but subjects with ADHD had less steep risk adjustment (Sorensen et al., 2016). The authors did not report on the quality of gamble.

In the original version of the CGT, potential bets are presented serially, and, consequently, participants have to wait until the bet they want appears. Such a characteristic may influence the choices of participants who are more delay-aversive. Therefore, for measuring probabilistic decision making, the inclusion of delays may mask basic risky tendencies. Two studies used a modification of the CGT in which delay-related processes were minimized by presenting optional sums of bet simultaneously, rather than serially. Children with ADHD showed poorer quality of gamble, lower risk taking, and similar risk adjustment (Kroyzer et al., 2014). These findings were replicated in a subsequent study, which also revealed that removing the feedback after each trial normalized performance of children with ADHD (Pollak and Shoham, 2015). See Table 1 for a summary of the findings.

Four of the CGT studies reported ADHD-related poorer quality of gamble, and two of them reported a lower sum of bet. What may explain such suboptimal, but at the same time conservative, decision making? Possibly, asking subjects with ADHD the obvious question, whether they prefer the more likely over the less likely gamble, challenged their trust in the fairness of the game, or simply confused them, leading them to doubt their understanding of the instructions, prefer unlikely gambles, and, at the same time to lower risk by betting smaller sums. The current study minimized this alternative account by removing the obvious question phase from the task. As in the previous studies from our laboratory, the willingness to avoid waiting for specific sums was also controlled for by presenting all possible sums simultaneously. Taken together, controlling for alternative accounts, this study aimed to test whether ADHD is linked with low sensitivity to risk.

Some studies suggested that compared to controls, subjects with ADHD increase risk taking when a gambling task is repeated (Drechsler et al., 2008; Ernst et al., 2003). The authors interpreted these findings as reflecting slower learning of the risks, a difficulty in shifting from non-strategic to strategic play, or an adoption of different response style. In contrast, another study did not find any practice effect (Pollak et al., 2016). The current study used a repeated game design to further examine the role of task repetition on risk preference of adults with ADHD.

Laboratory experimental tasks are constructed to model real-life phenomena. In our case, ADHD-related risk-taking behavior is the phenomena that should be modeled by experimental decision-making tasks. However, as it is often the case in psychiatry, the gap between real-life behavior and laboratory testing is not easy to bridge (Schonberg et al., 2011). In a recent paper, children with and without ADHD reported real-life engagement in risk-taking behaviors and performed decision-making tasks. Differences between groups were observed only in real-life, but not in experimental risk-taking behavior, and no correlation was found between these two measures (Pollak et al., 2016). The current study used the same strategy to examine the adequacy of another experimental decision-making task in modeling a different real-life risk taking of adults with ADHD.

In summary, the current study aims: 1. to examine probabilistic decision making in ADHD on a repeated gambling task, while minimizing and controlling for alternative accounts: the effect of the willingness to avoid waiting for an option, and of confusion/distrust elicited by asking participants to make an obvious choice. 2. To examine the relation between experimental decision-making task and real-life risk-taking behavior in subjects with ADHD.

2. Method

The study was approved by the Hebrew University of Jerusalem Institutional Review Board for research on human subjects. Written informed consent was obtained from participants.

2.1. Participants

Students from the Hebrew University of Jerusalem, with and without ADHD were recruited for the study. The following inclusion criteria were used for both groups: understanding Hebrew, and intact or corrected vision. Inclusion criterion for the ADHD group was a diagnosis of the disorder made by a qualified neurologist, psychiatrist or psychologist, confirmed by the ADHD module of the Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime Version (K-SADS-PL, Kaufman et al., 1997), adapted for adults. The exclusion criterion for the control group was a history of ADHD, which was ruled out using the same diagnostic tool. In order to control for the effects of other conditions on the CGT (Ernst et al., 2003), the following exclusion criteria for both groups were set: a history of a serious neurological illness (i.e., epilepsy, cerebral palsy) or severe head injury, a history of psychotic or bipolar depressive disorder, as well as meeting the diagnostic criteria for current substance use and