Emotion-Based Learning by Iowa and Bangor Gambling Tasks:
Similar but not the same?

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ABSTRACT

In 2004, the Bangor Gambling Task (BGT) was put forward as a simplified of the Iowa Gambling Task (IGT) - one of the primary experimental paradigms used to assess emotion-based decision making under uncertainty. We aimed to investigate the suitability of the BGT as a longer-term re-assessment tool of the IGT. Method: Using a $N = 176$ focused subsample of the large ongoing prospective cohort study Tracking Adolescents' Individual Lives Survey (TRAILS), we investigated three suitability criteria with regard to: 1) incremental learning patterns within each task, 2) correlation between the net-scores of tasks, and 3) within-level change in emotion-based decision-making by social stress as predicted by evolutionary theories. One out of three suitability criteria were met, that is, we found similar incremental learning patterns in gambling performance as reported in 2004, but no correlation between net scores of both tasks, nor a decrease in approach-related gambling choices in individuals exposed to social adversity versus controls. Although the BGT may be a useful tool for clinical neuropsychologists, it may be less suited to test changes in adolescents' decision making performance in combination with the IGT over a larger time frame.

INTRODUCTION

Emotion-based decision-making, the part of the decision-making process in which humans rely on internal cues of emotion, is key in many of individuals' everyday choices - particularly those made under complex and uncertain conditions. Adaptive emotion-based decision-making entails an appetitive orienting and activation to move toward reward and incentive (i.e., approach motivation), and aversive orienting and activation to move away from punishment and threat (Elliot et al., 2013). By contrast, maladaptive affective decision-making (Anderson et al., 1999; Bechara et al., 1994), is related to many forms of psychopathology (APA, 2013; NIH, 2011). To study the impairments in emotion-based decision-making, the Iowa Gambling Task (Bechara et al., 1994) is the key experimental paradigm.

In the IGT, participants are given money and are confronted with four closed decks of cards to gamble on. Without any further prior knowledge on the task, participants are told to pick one of the four decks to gamble on by turning a card and that the value of each picked card is labeled with a win or a loss; and instructed to make as much profit as possible. With every card turned, individuals gain information about the wins and losses across decks, which vary in amount and frequency. The deck payoff schedules are intended to be too complicated for participants to readily discern, forcing participants to rely on emotion-based signals throughout (Bechara, Damasio, Tranel, & Damasio, 1997). In this process of what feels like random picks, individuals generally tend to develop a preference for one of two decks that are most advantageous and, if sampled repeatedly, for which the total win outweighs the total loss.

In 2004, a simplified version of the IGT card game was developed by Bowman and Turnbull: the Bangor Gambling Task (BGT). Instead of four closed decks as in the IGT, in the BGT, only one closed deck of cards is presented. Furthermore, instead of being forced to gamble on one of the four decks, in the BGT, individuals have the choice to gamble and turn a card or to withdraw from a gamble and dismiss the closed card. Similar to the IGT, each card is labeled with a loss or a win, but instead of across decks, the reward-punishment contingencies now change through time. That is, unbeknownst to the participant, the deck consists of 5 blocks of 20 cards that have an increasing chance of loss and thus disadvantageous contingency. In a study comparing BGT to IGT gambling performance in 40 students, assessed 10 minutes apart, the tasks showed an analogous final level of performance of the overall individual scores ($r = .93$), with similar trajectories of emotion-based learning over time.

Given that the BGT is simpler to administer than the IGT, it constitutes a promising tool to assess patients with possible prefrontal dysfunction in clinical settings more quicker and easier (Adlam et al., 2017, 2009). In addition, the replaceable alternative to

measure the same construct opens up new possibilities to investigate changes over time. Being naïve to IGT is essential to adequate assessment of the emotion-based learning construct, and reassessment of IGT would induce large practice effects. Having a replaceable alternative available for the IGT enables within person re-assessment of emotion-based learning, and thus open-up many new exciting research opportunities. However, to the best of our knowledge, the long-term re-assessment suitability of the BGT and IGT has not yet been investigated.

In this study we addressed this gap, and investigated if the BGT and IGT may be suited to assess long-term changes in emotion-based learning. Given that the theoretical underpinnings of the BGT and IGT reside in approach-avoidance motivation (Bechara et al, 1997; Bowman & Turnbull, 2004), the BGT and IGT were assessed among normally developing adolescents of which some were naturally exposed to a social loss (i.e., death or serious illness of a loved one), a social defeat (e.g., beaten up), both of these social adversities, or none (i.e., control group). Adaptive functioning of the emotional-motivational system entails an appetitive orienting and activation to move toward reward and incentive (Elliot et al., 2013), and a decreased approach motivation during and after severe episodes of social stress (Allen and Badcock, 2003; Price et al., 1994; Watt and Panksepp, 2009). Although evolutionist have come to consensus that a decreased approach motivation is an adaptive response to social stress (for a review, see: Hagen, 2011; Nettle, 2004), they are inconclusive on whether the mechanism evolved in relation to social defeat (Price, Sloman, Gardner, Gilbert, & Rohde, 1994); social loss (Watt & Panksepp, 2009), or to social stress in general (Allen & Badcock, 2003).

If the BGT and IGT are suitable to assess changes in emotion-based learning over a longer time period, the tasks should meet the following criteria: 1) the incremental learning patterns in gambling performance over time during the tasks are similar to those found in the 10 minute re-assessment by Bowman and Turnbull (Bowman and Turnbull, 2004); 2) the net scores of the BGT and IGT should show at least a modest association. Furthermore, based on evolutionary theory, we would expect 3) a decrease in gambling performance in individuals exposed to social adversity versus controls.

METHODS

Participants

Was considered With the original goal to investigate changes in psychological functioning after healthy adolescents experienced stressful life events, the BGT and IGT were incorporated in a focused subsample of the large prospective cohort study of TRacking Adolescents' Individual Lives Survey (TRAILS). TRAILS is an ongoing,

multidisciplinary study into psychological, social and physical development of adolescents in which approximately 2700 adolescents participated every 2 to 3 years from age 10 to at least 25. All participants provided informed consent or assent for participation, and each assessment wave was approved by the Dutch Central Committee on Research Involving Human Subjects Act (WMO). For a detailed description of the sample selection, procedures, methods, and attrition rates, please see Huisman and colleagues (2008) and Nederhof and colleagues (Nederhof et al., 2012).

The BGT and IGT were incorporated in a battery of experimental tasks assessed in a focused subsample at the third and fourth wave of the community sample TRAILS. The subsample consisted of participants who 1) agreed to participate in the laboratory part of the third wave; 2) were assessed with the Life Stress Interview (LSI) at the fourth wave; 3) were, if LSI was rated a 3 or 4 on the severity and person-independency scales by two independent raters, assigned to either a social loss group (i.e., if they had been exposed to death and serious illness in their close environment such as family, or a close friends), social defeat group (i.e., if they had been a victim of bullying, sexual intimidation or violence or were dumped after a serious relationship), or control group (i.e., randomly selected from the pool of participants that experienced no loss or defeat, or a loss or defeat that was rated 1 or 2 on the severity and/or and person-independency scale); and 4) agreed to participate in reassessments of laboratory tasks at the fourth wave.

During the third wave of TRAILS ($N = 1816$; 81% of initial sample; mean age = 16.3), a focus sample of 744 adolescents were invited to a series of laboratory tasks, of whom 715 (96.1%) agreed to participate. The laboratory tasks took approximately three hours (starting and ending with a 40-min period of rest), and consisted of a number of different challenges, including the BGT.

During the fourth wave of TRAILS ($N = 1881$; 84% of initial sample; mean age = 19.1), 415 participants were *a)* asked about stressful events that occurred in the last two years assessed by trained interviewers using the LSI (Kendler et al., 1998) and *b)* had participated in the third wave laboratory tasks. Participants could list life stressors, and for each event the stressors were objectively rated by the trained interviewer on a 4-point context severity and a 4-point person-dependency scale. All interviews were tape-recorded and scored by a second rater blind to the interviewer's scores. In cases of discordant ratings, the two raters discussed the scores until consensus was reached, or a third rater made the final judgment. Immediately after all LSIs were conducted, 234 of the 415 were selected for reassessment of the behavioral experiments including the IGT, of whom 85% agreed to participate. Compared to the rest of the TRAILS sample, adolescents with at least one risk factor for mental health

problems had a slightly greater chance of being selected for the laboratory tasks. Nevertheless, the subsample did not differ on any of the risk factors (Bouma et al., 2009).

The total number of participants that completed both gambling tasks was 178. However, due to problems in coding, data from 1 control participant and 1 participant who experienced a social loss could not be retrieved, leaving a dataset of 176 participants. Of these participants, 107 had experienced stress (48 experienced a social defeat, and 76 experienced a social loss. There is overlap between these groups, because 17 had experienced both), and 69 had experienced no such stress (controls).

Procedure

Bangor Gambling Task (BGT)

In the BGT the participants were given €5,- in coins of €0.20, had a single deck of 100 closed playing cards in front of them, and were instructed to state clearly whether they wanted to gamble on the next card or not before the card was turned by the instructor. Money stakes would remain unchanged when they chose not to gamble, but if they wished to gamble, participants won or lose money in accordance with the affixed label on each card. Whereas the 38 high playing cards (i.e., Jack, King, Queen, or Ace) yielded various amounts of monetary gain (e.g., + €0.40), the 62 low cards (i.e., numbers between 2 and 10) implied a monetary loss (e.g., – €0.20). To prevent the adolescent from predicting when the game would end, 50 random cards were placed at the bottom of the deck. Unknown to the participants, the first 100 playing cards were sorted into five blocks of 20 cards, with increasing probabilities of losing money. The aim of the game was to maximize net rewards over time, and participants could keep the money they had left at the end of the game. In contrast to the official Bangor Gambling Task of Bowman & Turnbull (2004), participants did not regain new money to continue playing after depletion.

Iowa Gambling Task (IGT)

Whereas in the BGT the contingencies thus shift across time, in the IGT contingencies shift across decks. That is, comparable to the blocks of the BGT, participants could now choose to gamble from deck A, B, C, or D, each with varying contingency patterns. Participants were given €5.00 (10x € 0.10, 10x € 0.20, 4x € 0.50) worth of real money at the beginning of the task and told that they could keep any money they had left at the end of the game. The rewards in decks A and B were high (wins up to € 0.50 per card turned), and the rewards in decks C and D were significantly lower (€ 0.20 maximal). The rewards in deck A and deck C were thus high and low respectively, but both held five smaller unpredicted punishments per ten card selections. In a similar vein, the rewards in decks B and D were high and low respectively, but both held one very large unpredicted punishment per ten cards. The procedure was identical to the original IGT (Bechara, Damasio, Damasio, & Anderson, 1994), except that the task employed the Real Money reward system instead of play money as used in Bowman & Turnbull (Bowman and Turnbull, 2003).

Measures

Following Bowman & Turnbull (2004), in the BGT, participants' choice to *gamble* was considered a 'disadvantageous' choice, while participants' choice *not to gamble* was considered an 'advantageous' choice. Similarly, in the IGT, participants' choice to *gamble on deck A or B* was considered a 'disadvantageous choice, while participants' choice to *gamble on deck C or D* was considered an 'advantageous' choice. After subtracting the total number of 'disadvantageous' choices from the number of 'advantageous' choices, the net score above zero reflected mostly 'advantageous', and a net score below zero reflected mostly 'disadvantageous' decisions (i.e., BGT net score = nr of gambles – nr of non-gambles; IGT net score = nr of gambles on AB – nr of gambles on CD).

Data Analytic Strategy

By means of SPSS, version 23.0.0 (IBM Corp, 2015), we performed t-tests and a chi-square difference test to examine whether adolescents who experienced an adversity (i.e., social loss, social defeat, or both) differed from the control group in their demographic characteristics.

Next, to test the first criterion of suitability, that incremental learning patterns during the tasks are similar to those found by Bowman and Turnbull (2004), we first divided all card selections of the BGT and IGT into five blocks: card selections 1 - 20; card selections 21 - 40; card selections 41 - 60; card selections 61 - 80, and card

selections 81 - 100. Next, we ran a within subjects RM-ANOVA on the net scores by block (i.e., Block 1 - 5), task (i.e., BGT or IGT), and the interaction of both.

To test the second suitability criterion, that gambling performance assessed by BGT and IGT show a reasonable correlation, we calculated bivariate correlations between the net scores of the two tasks across the whole group, as well as the control group (i.e., only among those who were naïve to adversity).

Third, to test whether individuals exposed to social adversity showed a decrease in gambling performance as predicted by evolutionary theory, we performed a RM-ANOVA on the within-subject net scores, with stress groups dummy coded (i.e. social adversity versus control group) between-subject.

RESULTS AND DISCUSSION

The Iowa Gambling Task (IGT) is one of the primary experimental paradigms used to emulate real-life emotion-based decision making under uncertainty (Bechara et al., 1994). In 2003, the Bangor Gambling Task (BGT) was put forward as a simplified and easier to administer version of the IGT (Bowman and Turnbull, 2004). The aim of this study was to investigate the suitability of the BGT as a longer-term re-assessment tool of the IGT experimental paradigm, using a $N = 176$ subsample of the larger prospective cohort study TRAILS. Given that the theoretical underpinnings of the BGT and IGT reside in approach-avoidance motivation (Bechara et al, 1997; Bowman & Turnbull, 2004), and approach motivation is predicted by evolutionary theories to decrease during and after severe episodes of social stress (Allen & Badcock, 2003; Price, Sloman, Gardner, Gilbert, & Rohde, 1994; Watt & Panksepp, 2009), we administered the BGT and IGT approximately three years apart and in individuals who had experienced periods of severe social stress in between.

Demographic characteristics did not differ between those who had experienced an adversity and those who had not, except that when assessed with the IGT, adolescents who experienced an adversity were somewhat older than their peers in the control group (approximately twelve weeks; $t_{174} = -3.02, p = .003$). The adversity and non-adversity group did not significantly differ in: their age when assessed by BGT ($t_{174} = 0.39, p = .694$); the proportion of males ($\chi^2(1) = .617, p = .432$); SES ($t_{173} = 1.72, p = .087$); number of cards played during the BGT ($t_{174} = -0.09, p = .929$); and the amount of money left after gambling ($t_{174} = 1.60, p = .112$ for BGT; $t_{174} = 0.292, p = .771$ for IGT).

With regard to the first criterion of suitability of the BGT and IGT as long-term reassessment tools, the RM-ANOVA revealed a main effect of consecutive blocks of card selections ($F_{173,3} = 48.60; p < .001$), and task ($F_{175,1} = 17.37; p < .001$), meaning that

both tasks showed different incremental learning trajectories over time. The significant interaction between the learning trajectories prompted further analysis using post hoc t-tests ($F_{173,3} = 11.12; p < .001$). Paired t-tests showed a significant difference in Block 2 ($t_{175} = -5.80, p < .001$) and Block 3 ($t_{175} = -4.19, p < .001$), meaning that the incremental learning trajectories of the BGT and IGT significantly differed within these blocks of cards. The incremental learning trajectories are visualized in Figure 5.1, as well as the very similar trajectories as reported previously by Bowman & Turnbull (Bowman and Turnbull, 2004).

Figure 5.1. Emotion-based learning in overall net scores over five blocks of card selections in the Bangor Gambling Task (BGT) and Iowa Gambling Task (IGT).

Note. Upper figure reflects the incremental learning trajectories as observed by Bowman and Turnbull (2004). Lower figure reflects the incremental learning trajectories as observed in TRAILS. Bars represent standard errors.

With regard to the correlation between net scores between BGT and IGT, the second criterion of suitability, we found no Pearson correlation between the net scores of gambling tasks over time ($r_{176} = -.03, p = .669$; see Figure 5.2) nor in the control group that consisted of individuals who were naïve to adversity ($r_{69} = .02, p = .892$; see Figure 5.3). As depicted in Figure 5.2, the correlational pattern in overall net scores is very different from what was reported previously by Bowman & Turnbull (Bowman and Turnbull, 2004), who assessed the two tasks counter balanced and 10 minutes apart. The results remained unchanged when corrected for age ($F_{173} = -.04; p = .647$ and $r_{66} = .02, p = .897$ respectively). Finally, contrary to predictions from theory, we found no evidence for the third criterion. The experience of an adverse event, or potentially two, did not affect adolescents' subsequent net scores in advantageous minus disadvantageous choices ($F_{174, 2} = 1.39; p = .239$). The results remained unchanged when corrected for age ($F_{173, 3} = 1.08; p = .300$).

Figure 5.2. Correlation between overall net scores in the Bangor and Iowa Gambling Task.

Note. Net scores were calculated as good minus bad card selections. Upper figure reflects the incremental learning trajectories as observed by Bowman and Turnbull (2004). Lower figure reflects the incremental learning trajectories as observed in TRAILS.

Figure 5.3: Correlation between overall net scores in the Bangor Gambling Task (BGT) and Iowa Gambling Task (IGT)

Note. In the BGT participants selected 79-100 card, dependent on when they ran out of money; in the IGT participants all selected 100 cards. IGT was assessed approximately three years later. Correlations are split by participants' stress experience between tasks: a social loss (Stress), social defeat (Stress), both (Stress), or none of these experiences (No stress).

In sum, the BGT met one out of three suitability criteria for a longer-term re-assessment tool of the IGT. Compared to those previously reported by Bowman & Turnbull (2004), we found similar incremental learning trajectories, equal means of net scores with equally large SDs, but no correlation between the net scores over time. How could that be? Given that we administered the two tasks 3 years apart, and in a fixed order, our results may point to a potential order effect. That is, possibly, our results would have been different had we started with the IGT instead of the BGT. However, Bowman and Turnbull (2004) tried to rule out this potential order effects by assigning half the sample to the IGT first and half to the BGT first, and a .93 correlation in a counter balanced sequence is not suggestive of difference in outcome by the order of assessment of the two tasks.

Perhaps, adolescence is a too turbulent time to get a stable within-subject correlation. Whereas Bowman and Turnbull tested individuals with a mean age of 20.4 years ten minutes apart, we assessed the gambling tasks three years apart among individuals with a mean age of respectively 16.2 and 19.7 years. Compelling evidence shows that adolescents' brain reward system are in full development between the ages of 16 and 19 (Crone and Dahl, 2012; Somerville et al., 2010). However, in a large study on the IGT net scores across adolescence, the net score was found fairly stable across adolescence after the age of 13 (Cauffman et al., 2010).

Alternatively, it could be that the within-subject correlation of emotion-based learning is quite stable over time, but the two gambling tasks are less analogues in their performance than adjudged by Bowman & Turnbull in 2004. That is, the authors concluded that the BGT would provide a useful tool, as the task was proposed as easier and quicker to administrate and thus less burdensome to patient and researcher/clinician but analogues in performance to the IGT. Their judgment was based on the similarity they found in the general trajectories of the incremental learning profiles, the similar means, and the high correlation between the overall performance of the two tasks when assessed 10 minutes apart. In stark contrast with the $r_{40} = .93$ reported by Bowman and Turnbull (2004), however, our correlation with a nearly five times as large sample size was virtually zero – even when calculating the correlation in more homogeneous subgroups. More importantly, if the BGT and IGT would measure the same construct, and that construct is found fairly stable over time, one would still expect a small to moderate correlation between the two time points.

Replication of our findings is warranted and future research into test-retest reliability of the BGT-IGT may benefit from a pilot study using multiple populations of various ages and different time spans between assessments.

STRENGTHS AND LIMITATIONS

This study had several strengths. First, we had a considerably large sample providing power for, and confidence in, the outcomes of the analyses that were conducted. Second, our prospective data were collected as part of the large and renowned TRAILS cohort study. Third, we investigated the long-term test-retest reliability of the BGT and IGT in a unique focused subsample of TRAILS, as we were able to compare gambling performance between individuals who were and who were not exposed to circumstances that likely affect one's gambling performance.

Despite its strengths, the study also has some limitations. First, the TRAILS sample is known as a very representative sample but due to the selection based on adverse experience our subsample had a slightly larger risk of mental problems. Second, not all participants were able to gamble the last 20 cards of the BGT, and the overall net scores could have been somewhat less disadvantageous for these participants if money was renewed. Third, whereas one TRAILS-finding concerning the BGT was in line with the authors' expectations TRAILS, two other TRAILS-studies reported null-findings or even results contradictory to the authors' expectations TRAILS. Although we found similar visuals, we cannot exclude the possibility that the task was assessed differently or perhaps less accurate in TRAILS compared to the study of Bowman and Turnbull (2004).

CONCLUSION

In contrast to the high correlation reported by Bowman & Turnbull in 2003, we found a zero correlation when the two tasks were administered approximately three years apart. In combination with the similar incremental learning patterns we found during the two tasks, our results suggest that the BGT and IGT may share similar performance features but possibly not on the

same construct. Although the BGT may be a useful tool for clinical neuropsychologists, in combination with the IGT it may be less suited to test changes in adolescents' emotion-based learning over a larger time frame.

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