Individual Differences in Performance on Iowa Gambling Task are Predicted by Tolerance and Intolerance for Uncertainty

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Abstract

Iowa Gambling Task (IGT) is frequently used to index individual differences in decision-making under uncertainty, particularly in atypical (clinical) populations. However, it is rarely analyzed as a learning task, and research on the predictors of performance on the IGT in normative populations is scarce. Here, we focused on tolerance and intolerance for uncertainty as two traits that could potentially influence subjects' IGT performance. Using mixed modeling analysis of longitudinal experimental data (n=60, 5 blocks) we showed that tolerance for uncertainty predicted the initial level of risk in IGT as manifested in the proportion of "bad decks" chosen; at the same time, intolerance for uncertainty predicted explorative learning in IGT as manifested in the number of deck switches after a loss and its decline over the course of the experiment. The results are discussed in the context of viewing IGT as capturing a set of dynamic decision making processes that rely on learning, risk taking, and exploration.

Keywords: decision making; learning; Iowa Gambling Task; tolerance for uncertainty; intolerance for uncertainty; risk

Introduction

Despite a considerable body of research generated in the field of decision making in the recent several decades, sources of individual differences in decision making remain largely understudied, in part due to the absence of well-established individual differences-focused research paradigms (e.g., see Jackson & Kleitman, 2014). Moreover, when individual differences in decision making become the focus of the investigation, such studies frequently center around cognitive traits (i.e., intelligence and emotional intelligence) and the "traditional" set of Big Five personality traits to explain participants' performance on tasks like the Iowa Gambling Task (IGT). Finally, although inherently an experimental learning task, IGT is rarely analyzed in terms of participants' trajectories over time. The study reported in this paper aimed to partially address these three gaps in the literature by investigating the role of the complex traits of tolerance and intolerance for uncertainty in participant's learning during decision making under uncertainty in the IGT task.

The IGT requires the participant to choose cards from four decks that have a systematically varied intermittent gain and loss structure that the participants uncover by trial and error during the experiment. The two disadvantageous IGT decks (A and B) are associated with high immediate rewards but long-term net losses. The two advantageous decks (C and D), on the other hand, are associated with lower immediate rewards but also significantly smaller long-term losses. Initially used to test the somatic marker hypothesis in patients with lesions to the ventromedial prefrontal cortex (Bechara, Damasio, Damasio, & Anderson, 1994), IGT has since been productively used with clinical (e.g., psychiatric and neurological) as well as developmental (i.e., adolescents) populations to study decision making.

Perhaps surprisingly, a recent review of the associations between participants' performance on the IGT task and cognitive traits found that IGT performance was largely unrelated to general cognitive ability, working memory, executive functions, and set shifting, although no aggregate effect sizes were computed (Toplak, Sorge, Benoit, West, & Stanovich, 2010). These results highlighted the distinction between cognitive processes captured by the maximum performance (i.e., intelligence testing) measures and measures of rational decision making. At the same time, participants' performance on IGT was found to be modulated by trait anxiety and neuroticism (Hooper, Luciana, Wahlstrom, Conklin, & Yarger, 2008; Miu, Heilman, & Houser, 2008). At the same time, personality correlates of participants' performance on the IGT task have rarely been examined in non-clinical samples (Buelow & Suhr, 2009).

Note that IGT performance is most frequently analyzed in terms of the resulting proportion of disadvantageous choices to all choices [(A+B)/(C+D)] in the second half of the experiment (that typically consists of 5 blocks of 20 trials, for a total of 100 trials) or the overall game money net gain by the end of experiment. Yet, the IGT task can also be considered to be a learning under uncertainty task where participants are faced with the neccessity to establish and continuously refinine probabilistic representations of the reward and punishment structure of the environment (i.e., the experimental deck setup). Correspondingly, decision making in IGT unfolds over time and within-participant learning trajectories can be established and related to individual differences in participants' basic cognitive and personality characteristics.

Uncovering these trajectories and explaining them from the standpoint of individual differences was the main aim of the reported study. Based on our previous findings of the importance of tolerance and intolerance for uncertainty for understanding the nature and mechanisms of decision making, we hypothesized that longitudinal indices of IGT performance should be related to traits of tolerance and intolerance for uncertainty as capturing the fundamental regulatory elements of decision making (Chumakova & Kornilov, 2013; Kornilova, 2013).

Methods

Participants

The participants were undergraduate students from Moscow State University and military instructors. A total of 60 adult participants took part in the study (age ranged from 18 to 52, M = 30.58, SD = 10.61; 41 were males, and 19 were females).

Iowa Gambling Task (IGT)

All participants were first administered the Iowa Gambling Task, followed by personality assessments. For the purpose of the study, we translated and adapted the standard computerized IGT protocol developed by Grasman and Wagenmakers (Grasman & Wagenmakers, 2005). Briefly, participants were instructed to choose cards from one of four decks presented on the screen – A (+$100 or -$150, -$200, -$250, -$300, -$350 with a probability of 50%); B (+$100 or -$1,250 with a probability of 10%); C (+$50 or -$50 with a probability of 50%); D (+$50 or -$250 with a probability of 10%). The experiment was organized in 5 blocks of 20 trials, and feedback was provided after each trial on the screen of the computer, along with the feedback regarding the participant's overall progress on the task (i.e., net gain and losses).

We analyzed the following indices of performance on the IGT: 1) cumulative Net Gain, 2) proportion of disadvantageous deck choices (Bad Decks) to total deck choices, and 3) proportion of deck switches after experiencing a loss (Loss Switches). Participants' performance was averaged across 20 trials within each of the five blocks, and the resulting data were subjected to mixed modeling (or growth curve) analysis (see below).

New Questionnaire of Tolerance for Uncertainty (NTN)

The previously validated New Questionnaire of Tolerance for Uncertainty (NQTU, or NTN in Russian) was used to measure variables associated with acceptance of uncertainty (Kornilova, 2010). This self-report questionnaire showed superior psychometric properties compared to other existing measures of the same construct(s). We used the following two subscales of the NQTU for the purpose of the study - Tolerance for Uncertainty and Intolerance for Uncertainty. Tolerance for Uncertainty (TU) was conceptualized as the readiness to make decisions and act in uncertain situations, openness to new ideas, changing stimuli and changing thinking strategies. In the original structural equation model (SEM) reported in Kornilova's (2010) study, TU was one of the indicators of the latent variable of acceptance of uncertainty and risk (which also included experiential/intuitive thinking style). In this model, tolerance for uncertainty was a construct relatively independent of intolerance for uncertainty. Intolerance for Uncertainty (ITU) was conceptualized as willingness to achieve clarity in the world (including the world of ideas), rejection of uncertainty in judgement, rigidity and rationality (directed towards acquiring maximum information required for decision making).

Results

The data were analyzed using a set of mixed linear models (Baayen, 2008) as implemented in the *lme4* R package (Bates & Maechler, 2010). Net Gain, Bad Decks, and Loss Switches were used as dependent variables. Block number, sex (0=females, 1=males), and TU/ITU scores were entered in the model as fixed effects. Block number was centered at the value of 1, age and TU/ITU scores were mean-centered. The unconditional growth models also included the quadratic growth term when appropriate (as determined by a set of comparisons of nested models). In conditional growth models, age, sex, and ITU/TU predicted both the intercept and the growth parameters. Intercept and growth parameters were also included as random effects in all of the models.

First, we found that over the course of the experiment, participants exhibited significant learning that could be described by a quadratic function (see Table 1). There was a trend for the association between participant's net gains for the first IGT block (i.e., the intercept parameter) and TU (B = 5.68, SE = 2.93, t = 1.94), suggesting that tolerance for

Table 1 : Summary of Fixed Effects for the Mixed Models with IGT Performance as Dependent Variables

	Net Gain			Bad Decks			Loss Switches		
Parameter	*B*	*SE*	*t*	*B*	*SE*	*t*	*B*	*SE*	*t*
Intercept	1514.06	52.70	28.73*	.53	.05	10.39	3.85	.50	7.72
Block	1557.07	78.10	19.94*	-.04	.02	-2.03*	-.32	.55	-.58
Sex	104.97	70.63	1.49	.07	.07	1.09	.85	.67	1.27
Age	-3.46	2.86	-1.21	-.002	.003	-.90	-.03	.03	-1.22
TU	5.68	2.93	1.94^t	.006	.003	2.13*	-.04	.03	-1.51
ITU	1.25	2.23	.56	.002	.002	.90	-.05	.02	-2.32*
Block^2	-26.13	12.45	-2.10*	n/a	n/a	n/a	.05	.13	.38
Block:Sex	-8.01	104.68	-.08	.02	.03	.93	-.40	.73	-.55
Block:Age	.42	4.24	.10	-.001	.001	-.60	.02	.03	.52
Block:TU	6.18	4.34	1.42	-.002	.001	-1.42	.03	.03	1.12
Block:ITU	3.59	3.30	1.09	-.001	.001	-.71	.05	.02	2.14*
Block^2:Sex	23.09	16.69	1.38	n/a	n/a	n/a	-.02	.17	-.10
Block^2:Age	-.63	.68	-.94	n/a	n/a	n/a	-.0002	.007	-.02
Block^2:TU	-.93	.69	-1.34	n/a	n/a	n/a	-.008	.007	-1.17
Block^2:ITU	-.56	.52	-1.07	n/a	n/a	n/a	-.01	.005	-1.86^t

Note. * - $p < .05$; ^{t} – $p < .10$. TU – tolerance for uncertainty; ITU – intolerance for uncertainty

uncertainty modulates the baseline IGT performance level.

We also found that the proportion of Bad Decks decreased over the course of the experiment linearly. Importantly, TU was a significant predictor of the baseline level for this dependent variable (*B* = .006, *SE* = .003, *t* = 2.13), corroborating results reported in the previous paragraph.

Finally, we found that Loss Switches were relatively constant over the course of the experiment for our "average" participant. Yet, ITU predicted the baseline level (*B* = -.05, *SE* = .02, *t* = -2.32), with higher ITU associated with lower number of deck switches after losing experimental money. ITU also predicted the linear growth parameter (*B* = .05, *SE* = .02, *t* = 2.14) and showed a trend for a significant association with the quadratic growth parameter as well (*B* = -.01, *SE* = .005, *t* = -1.86). This result suggests that individuals with higher ITU are less likely to explore other decks after losing money in the beginning of the experiment, and potentially, display a relatively constant (or slightly increasing, compared to constant or slightly negative average growth rate, see Table 1) level of deck switching throughout the course of the experiment.

Discussion

The reported study investigated individual differences in the dynamic indices of decision making as captured by the IGT. We found that tolerance and intolerance for uncertainty predicted several of these indices, suggesting that these traits modulate decision making on-line.

Tolerance for uncertainty predicted the participant's baseline performance on the IGT – i.e., individuals with higher tolerance for uncertainty were more likely to choose disadvantageous decks in the beginning of the experiment, and yet showed higher net gains than individuals with lower tolerance for uncertainty. These results suggests that tolerance for uncertainty regulates baseline risk taking propensity during online decision making under uncertainty, consistent with previous reports of TU being linked to risk taking (Kornilova, 2013) and reports of significant associations between IGT performance and sensation seeking (Suhr & Tsanadis, 2007). Given that we also found a trend for TU being a positive predictor of baseline IGT net gain, these results suggest that TU indexes processes that play important roles in environment sampling and the development of probabilistic representations (i.e., learning that manifests in disadvantageous decks aversion) at the initial stages of decision making that determine the baseline "performance corridor".

On the other hand, we found that higher intolerance for uncertainty was associated with lower baseline exploratory activity after failure (i.e., number of deck switches after experiencing a monetary loss in the IGT). This finding is consistent with viewing intolerance for uncertainty as indexing risk aversion and uncertainty rejection (Kornilova, 2010) and recent reports of ITU being associated with avoidant behavior in decision making under uncertainty (Luhmann, Ishida, & Hajcak, 2011).

Overall, the results of our study indicate that decision-making under uncertainty is partially modulated and regulated by tolerance and intolerance for uncertainty. Interestingly, TU appears to regulate baseline risk propensity that underlies exploratory learning at the initial stages of decision making, while ITU regulates risk propensity after failure/loss, potentially constraining learning under uncertainty through risk aversion and outcome sensitivity.

Our study was also instrumental in showing the added value of investigating dynamic (as opposed to static) indices of decision making in the IGT task. Future studies should investigate the incremental predictive value of TU/ITU with respect to IGT performance over and above cognitive traits (i.e., nonverbal and verbal intelligence, working memory, and executive functions) in larger samples and attempt to clarify the mechanistic role of TU and ITU in constraining the online development of probabilistic representations and risky exploratory behavior under uncertainty.

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