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Research / Araştırma

Iowa Gambling Test: Normative Data and Correlation with Executive Functions

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ABSTRACT

Iowa Gambling Test: normative data and correlation with executive functions

Objective: Purpose of the study was to establish the normative values of the Iowa Gambling Test (IGT) in Turkey, using scores from 90 healthy participants aged between 20 and 86.

Method: Participants were classed into 3 groups according to age and education level, and the test was administered in two sessions: in the first session (IGT1), IGT and neuropsychological tests assessing executive functions, and in the second session (IGT2), only IGT.

Results: Statistical analyses showed that IGT performance was not affected by age or education, but male participants performed significantly better in IGT2 than women. Both gender groups performed significantly better in IGT2 than in IGT1 and increased their total net score in IGT2. A statistically significant correlation was found between executive function performance assessed with Wisconsin Card Sorting Test, Stroop Test and Tower of London Test and IGT performance.

Conclusion: The comprehensive assessment of the correlation between decision-making behavior, demographic variables, and executive functions needs to be continued with larger sample groups.

Keywords: Decision-making behavior, executive functions, Iowa Gambling Test (IGT), normative data, risk-taking behavior

ÖZET

Iowa Kumar Testi: Normatif veriler ve yürütücü işlevlerle ilişkisi

Amaç: Çalışmanın amacı, yaşları 20-86 arasında değişen 90 sağlıklı katılımcıdan elde edilen puanlar ile Iowa Kumar Testi (IKT)'nin Türkiye'deki normatif verilerine dair bilgi edinilmesidir.

Yöntem: Katılımcılar yaş ve eğitim durumlarına göre 3 farklı gruba ayrılmış ve uygulama 2 oturum şeklinde gerçekleştirilmiştir. İlk uygulama, IKT (IKT1) ve yürütücü işlevleri değerlendiren nöropsikolojik testleri; ikinci uygulama ise sadece IKT (IKT2)'yi içermiştir.

Bulgular: İstatistiksel analizler, IKT performansının yaş ve eğitimden etkilenmediğini fakat erkek katılımcıların IKT2 performansında kadınlardan anlamlı olarak daha iyi performans gösterdiklerini bulgulamıştır. Her iki cinsiyet grubu da, IKT2 performansında, IKT1 performansından anlamlı olarak iyi performans göstermişler ve IKT2 toplam net puanlarını arttırmışlardır. Wisconsin Kart Eşleme Testi, Stroop Testi ve Londra Kulesi Testi ile değerlendirilen yürütücü işlev performansı ve IKT performansı arasında istatistiksel olarak anlamlı bir ilişki bulunmamıştır.

Sonuç: Karar verme davranışı, demografik değişkenler ve yürütücü işlevler arasındaki korelasyonun kapsamlı değerlendirilmesine büyük örneklemli gruplarda devam edilmesi gerekmektedir.

Anahtar kelimeler: Karar verme davranışı, yürütücü işlevler, Iowa Kumar Testi (IKT), normatif veri, risk alma davranışı

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INTRODUCTION

Being able to implement decision-making behavior reliably in daily life is an important mental process; hence, any disorder affecting the capacity to make decisions or to understand the outcomes of those decisions can lead to financial, social, and health problems that have a negative impact on our lives (1). Decision-making behavior disorder may result from problems in affective event processes before the selection of behavior that precedes making a decision or in operations processing feedback from previous experiences, or it may derive from disorders of the executive functions. In addition, the mechanisms

underlying this disorder may be related to the level of uncertainty and the amount of knowledge about the situation available to the decision maker (2-4). Therefore, decision-making behavior under conditions of uncertainty can be defined in two ways, as decision-making in risky situations with known probabilities and decision-making in uncertain situations where probabilities are unknown (5). In decision-making under uncertainty, the outcome of the choice is completely unclear; it may be advantageous or disadvantageous. In decision-making under risk, on the other hand, the probable outcomes and potential gains or losses are known, and in such a case, decisions are made by applying the available knowledge to analyze the potential outcomes and establish the long-term losses and gains (1). Neuropsychology can contribute to the understanding of the psychological processes and neuroanatomical structures underlying decision-making in different situations. In this context, over the last years the interest in studies researching decision-making and related reversal learning has grown. Reversal learning refers to a mental plasticity allowing to reverse a behavior when the conditions reinforcing it change. Such mental plasticity includes being able to make use of positive or negative feedback received after a specific behavior and to reassess that behavior, which is no longer being reinforced, retroactively (6). Maia and McClelland (7) tried to explain the behavioral disorder seen in patients suffering from ventromedial prefrontal cortex (VMPC) lesion with an impairment of the capacity for reversal learning. IGT was developed by Bechara et al. (8-10) as a neuropsychological test to assess the decision-making disorder in patients with VMPC lesion, taking into account the elements of uncertainty, gain, and loss; eventually the authors demonstrated that they could evaluate this disorder consistently. During the IGT, participants are required to choose from four different decks of cards and increase the amount of money they own. The participants do not know which card they should choose, nor how much money they will gain or lose with each card. Thus, the participants are finding themselves continuously in a state of uncertainty, no matter if they are choosing from the disadvantageous or the advantageous deck. Of the four decks, the disadvantageous ones allow to gain a large amount of money but also occasion great losses; because of the danger of significant losses, they are defined as high-risk. The advantageous ones provide small gains, but also incur small losses, and are thus safer in the long term. It is expected that the participants learn this condition as the test goes on, through the information displayed on their screen after their selection, telling them how much money they have gained or lost (1). While participants with a good performance in the IGT learn to avoid the disadvantageous decks and choose from the advantageous ones (10), substance addicts, patients with orbitofrontal and ventromedial lesions, AIDS patients, schizophrenics, and patients with diagnoses of Parkinson, Huntington or anorexia nervosa as well as pathological gambling addicts continue to choose from the disadvantageous decks throughout the test (11-14).

For the IGT, a normative data study with a broad sample group has not yet been carried out in Turkey. The present study is a pilot study with normative data from healthy Turkish participants. It aims to determine if IGT performance displays differences related to demographic factors such as age, gender, or education, to see the effects of learning on the performance in re-administration of the test, and to assess the association of various executive functions with the test performance.

METHOD

The study group consisted of 90 individuals (45 women, 45 men). Participants were recruited by oral invitation from among university students, employees at various institutions and workplaces, and residents of nursing homes. They gave written consent and agreed voluntarily to participate; no financial payments were made to them. Each participant reported that he or she was not under treatment for any neurological or psychiatric disorder, and for the elderly nursing home residents, information about drugs they were using and if they were suffering from any psychiatric or neurological disease was received. Neurological or psychiatric patients or those with a

history of stroke or head trauma did not participate in the study (whereas e.g., diabetics not suffering from serious complications, hypertension patients or participants with low-level hearing loss were not excluded from the study). The participants' age ranged between 20 and 86 years (mean:47.9, SD:15.4), duration of education was between 5 and 21 years (mean:10.3, SD:4.3). Participants' total years of education were divided into three levels and analyzed as categorical variables. Those three levels were determined on the background of the Turkish education system as "low education" (5 years), "intermediate education" (6-11 years), and "high education level" (12 years and more). The first level consisted of participants with only primary school education; participants in the second group had continued after primary school, studying in middle and high school, and were either graduates or had dropped out from these schools, while the third level consisted of participants who were either graduates from universities and higher education institutions or were still enrolled in those schools.

Measures

Iowa Gambling Test: This study uses the IGT in the computerized version developed by Bechara et al. (10,15). The English terms and dollar units were changed within the software into Turkish terms and Turkish Lira (TL) units. In this version, IGT gives each participant at the beginning an advance of 2000TL. On the screen, four decks of cards are displayed. The participants are told that their aim should be to earn money beyond the 2000TL and by the end of the test to gain the maximum amount of money through selections they made on their screen (10,15). During the test, a total of 100 cards will be selected, but this information is not given to the participants. Before starting to select from the decks, the participants receive the following instruction:

"On the screen, you see four cards: A, B, C, and D. I want you to choose any one of these cards, using your mouse. With any chosen card, you will earn a certain amount of money. How much money you have won will be shown on the screen. While the test continues, as you win money, you will also start losing money. How much money you have lost will be shown on the screen. You can choose any card you like. You can choose the same card repeatedly. Aim of the game is to earn as much money as possible and to lose as little as possible. With any card selection, you can find out the amount of money you have displayed in the corner of the screen. I will not tell you when the game is over, thus continue to choose until the program informs you on the screen that the test is complete."

For the IGT performance, a total net score and five separate net scores obtained from 20 cards each are being calculated. The total net score results from the subtraction of the disadvantageous deck choices from the advantageous deck choices during the entire test ([C'+D']-[A'+B']). The same procedure is applied for the 20-card selections and thus for each block five separate net scores are obtained.

Tower of London Test: Standardization of the Tower of London Test (TLT) used in this study was carried out by Culbertson and Zillmer (16) for children and adults. Its standardization and reliability for Turkey were validated by Atalay and Cinan (17). For adults, the test consists of 10 test problems. The test also includes 1 sample problem and 2 training problems (16). In the test evaluation, seven scores are calculated. Score for the total number of moves, results from the calculation of the number of moves made in excess of the necessary minimum number of moves for each problem. This score provides information about the quality of the participant's executive planning ability. The lower the number of additional moves, the better the participant is at producing planned solutions. Score for totally correct solutions, shows the minimal number of moves, or rather, the number of completely correctly solved problems, thus demonstrating the level of the participant's planning and problem solving ability. Total rule violations score, demonstrates the participant's ability to take on and control executive planning and problem solving behavior under specified rules; total time violations score, reflects the participant's ability to plan and solve problems within a specified period of time (if a person exceeds 1 minute, he or she is counted

as having committed a time violation). During the test, three time scores are to be calculated. Each of these scores is calculated in seconds. Initiation time, is the time passing between submitting the problem to the participant and the beginning of the first move. If we consider the initiation time score together with the total number of moves score, it shows the effective planning ability prior to the problem solving response. Total execution time, is the time from the start of the first move to the completion of the problem solving. The execution time score shows how fast the test problems were solved. Total problem-solving time, consists of the total initiation time score and the total execution time score, establishing how much time the participant uses during the entire test (16).

Wisconsin Card Sorting Test: The Wisconsin Card Sorting Test (WCST) has been standardized for Turkish within the "Neuropsychological Test for Cognitive Potentials" (BİLNOT) battery (18). In our study, we used the computerized version of the WCST obtained from the neuropsychology laboratory of Istanbul University's Neurology Department. In this version, the four stimulus cards that WCST contains are shown on a computer screen. Among the 4 cards on the screen, there is the one that the participant needs to match according to the test rules. After the participant has matched all cards, on the screen the word "right" (in English) will appear if the matching was correct, or "wrong" if it was not. In order to enable participants to benefit correctly from the English feedback, they were told verbally by the test administrator the meanings of the words "right" and "wrong". In this test, a total of 13 scores is calculated: total number of trials, total number of errors, total number of correct answers, categories completed, number of perseverative responses, total number of perseverative errors, number of non-perseverative errors, number of conceptual level responses, conceptual level response percentage, failure to maintain set score, learning to learn score (18,19). In this version of the test, the computer records the sequence in which each participant selected which cards and calculates how many points they score.

Stroop Test: In the literature, there is not merely one Stroop Test. In this study, we used the Stroop Test included in the BİLNOT battery standardized for Turkish (18). In this form, there are 4 cards altogether, and on each card there are 6 rows with 4 items each, randomly allocated. On the first card of the test, names of colors (the words blue, green, red, and yellow) are printed in black. On the second card, there are the names of colors (the words blue, green, yellow, red) printed in blue, green, red, and yellow. On this card, the color of each word is different from the color it refers to. On the third card, there are circles printed in blue, green, red, and yellow. On the fourth card, there are neutral words (amount, weak, as to, middle) printed in blue, green, red, and yellow. The administration of the Stroop Test results in 3 different scores, namely, time (in seconds) between the "start" command given to the subject until the reading of the card's last entry, number of errors, and number of subject's corrected responses (20). One score is also the time difference between the first run, where the participants only read the words written on the second card, and a second run where the participants say the color in which the words are written on the second card (interference).

Procedure

The participants were divided according to age and educational status into 3 different groups (20-39, 40-59, 60-60+). When dividing the participants into the age groups, previously administered IGT studies were taken into consideration. In normative data studies, while there was a distinct specification regarding age groups, as a baseline, the normative data were obtained from age groups with a significant difference between them. According to their level of education, the participants were divided into three groups (low level of education: primary school graduate; intermediate level of education: middle school or high school graduate; high education level: university, college, postgraduate graduate). During the test administration, firstly IGT and a neuropsychological test battery consisting of executive function tests (WCST, TLT, Stroop Test) were

Table 1: Participants' demographic characteristics

	20-39 years (n=30)	40-59 years (n=30)	60-60+ (n=30)
Gender (women/men)	(15/15)	(15/15)	(15/15)
Age (mean±SD)	30.46±5.53	46.86±4.88	66.26±6.93
Education years (mean±SD)	10.23±4.27	11.00±4.29	9.54±4.36

SD: Standard deviation

administered. The second administration (IGT2) was carried out in the 4th or 5th week after the first one, assuming that having learned the test rule, the learning effect will not pass and the length of time will not lead to forgetting the rule; the development of the performance in the repeated administration of IGT was assessed. For the completion of the repeat test administration, the same version of IGT as in the first run was used.

All data from the study were analysed using the SPSS 21.0 package for Windows.

RESULTS

Demographic characteristics Normative data in this study were obtained from 90 participants (45 women, 45 men). Table 1 shows the participants' demographic characteristics. The participants' age ranged from 20-86 years (mean:47.9, SD:15.4) and the average number of completed years of education was calculated as 10.3 (SD:4.3).

Effects of Age, Education, and Gender on IGT and Various IGT Parameters

Before statistically assessing the correlations between the variables in the study, they were first tested for normal distribution and the presence of extreme values. Results of the Levene test found that IGT scores according to the participants' age, education, and gender showed a normal distribution and the group variance was homogeneous with a 95% confidence interval (respectively: F[2.87]=0.465, F[2.88]=0.635, F[2.87]=0.605).

The effect of the age variable on the IGT performance was tested using a one-way analysis of variance. This analysis showed that there is no significant difference regarding the IGT1 net score ($F_{2.87}$=0.27, η^2=0.00, p=0.76, mean±$SD_{(young)}$=2.00±17.00, mean±$SD_{(adult)}$=0.44±16.50, mean±$SD_{(elderly)}$=3.45±12.80) and the IGT2 net score ($F_{2.87}$=2.02, η^2=0.04, p=0.13, mean±$SD_{(young)}$=15.80±18.60, mean±$SD_{(adult)}$=20.00±12.60, mean±$SD_{(elderly)}$=11.03±19.00).

The effect of the education variable on the IGT performance was tested using a one-way analysis of variance. This analysis showed that there is no significant difference regarding the IGT1 net score ($F_{2.87}$=0.66, η^2=0.01, p=0.51, mean±$SD_{(low)}$=4.73±19.66, mean±$SD_{(interm.)}$=1.00±12.50, mean±$SD_{(high)}$=0.46±13.81) and the IGT2 net score ($F_{2.87}$=0.06, η^2=0.00, p=0.93, mean±$SD_{(low)}$=16.00±18.09, mean±$SD_{(interm.)}$=14.40±15.91, mean±$SD_{(high)}$=15.53±18.75).

To assess the effect of the gender variable on the IGT performance, for each IGT measurement t test was applied. Between the IGT1 net scores (t_{88}=1.18, p>0.05; mean±$SD_{(women)}$=0.13±17.53, mean±$SD_{(men)}$=4.00±13.26), no significant difference was found regarding gender; however, the men's net scores in IGT2 (t_{88}=2.79, p<0.01; mean±$SD_{(women)}$=10.35±17.87, mean±$SD_{(men)}$=20.26±15.67) were significantly higher than the women's.

In order to study the performance effect and reliability of IGT related to learning, all participants were administered the IGT again in the fourth or fifth week after the first administration. The result of Pearson correlation analysis showed no significant correlation between the IGT1 and IGT2 net scores.

In order to assess if participants in IGT1 during the procedure of the test chose more from the advantageous decks and thus over time the net scores in the five blocks increased, for the repeat measurements analysis of variance was performed, which showed that participants in IGT1 (F[15.85]=17.306, η^2=0.449, p=0.00) increased their

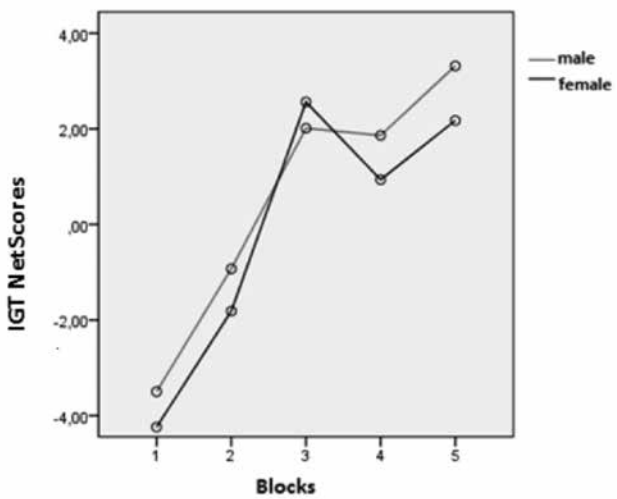

Figure 1: Change of IGT net scores for male and female participants over 100 cards

net scores in each block significantly, while no difference between these increases by gender was found (Figure 1).

Correlation of IGT Performance with other Executive Functions

In our study, the analysis included the following data: from the Stroop Test, scores for spontaneous correction, error number, and the interference difference score corresponding to the time difference for the second card between the first and second administration; from the TLT, total number of correct answers and total number of moves, demonstrating the planning and problem-solving function, initiation time to assess effective planning ability, and total execution time, showing how fast the test had been completed; from the WCST, the number of categories completed, measuring conceptual processing functions, the number of perseverative responses and percentage of perseverative errors, and the failure to maintain set score corresponding to the measurement of attention and concentration functions. The correlation between the specified scores and the IGT1 net scores was assessed with Pearson correlation analysis; no significant correlation between the variables was found (Table 2).

Table 2: Correlation between executive function test scores and IGT1

	IGT1 Net Score	
	r	p
Stroop Spontaneous Correction	0.171	0.106
Stroop Error Number	0.003	0.976
Stroop Interference Difference	0.057	0.592
TLT* Totally Correct Score	0.161	0.129
TLT Total Execution Time	0.630	0.552
TLT Total Number of Moves	0.060	0.571
TLT Initiation Time	0.135	0.204
WCST Categories Completed**	-0.018	0.870
WCST Perseverative Responses	-0.127	0.234
WCST Perseverative Error Percentage	-0.131	0.220
WCST Failure to Maintain Set	-0.029	0.787

*Tower of London Test, **Wisconsin Card Sorting Test

Table 3: Normative data for net scores in IGT1 and IGT2 (the latter by gender)

	IGT1 Net Score	IGT2 Net Score Men	IGT2 Net Score Women
n	90	45	45
Mean±SD	15.31±17.44	20.26±15.67	10.35±17.87
Median	14	3	10
10-20 percentile	-12.0 / -3.6	-18.0 / -10.0	-6.0 / 4.0
20-25 percentile	-3.6 / -1.0	-10.0 / -8.0	4.0 / 5.5
20-30 percentile	-1.0 / 1.6	-8.0 / -4.0	5.5 / 6.6
30-40 percentile	1.6 / 6.0	-4.0 / 0.0	6.6 / 10.0
40-50 percentile	6.0 / 10.0	0.0 / 3.0	10.0 / 14.0
50-60 percentile	10.0 / 13.2	3.0 / 5.2	14.0 / 21.2.0
60-70 percentile	13.2 / 22.0	5.2 / 8.0	21.2 / 26.0
70-75 percentile	22.0 / 23.0	8.0 / 8.5	26.0 / 26.5
70-80 percentile	23.0 / 27.6	8.5 / 17.2	26.5 / 29.6
80-90 percentile	27.6 / 36.8	17.2 / 22.0	29.6 / 39.8

SD: Standard deviation

Normative Data

Based on the analyses of demographic variables, normative data were calculated in two ways. These are the total net scores obtained by the participants in the administrations IGT1 and IGT2. Given that in IGT2 a statistically significant gender difference was found, the IGT2 score norms have been determined separately for women and men (Table 3).

DISCUSSION

Aim of this study was to collect normative data for the performance of healthy Turkish participants in the Iowa Gambling Test developed by Bechara et al. (10,15). The participants were divided into different age and education groups (20-39, 40-59, 60-60+; low, intermediate, high).

The IGT is a test for standard neuropsychological evaluation, developed to assess the decision-making behavior of patients with ventromedial prefrontal lesions, which do not result in any disorder in the executive functions but affect the decision-making ability in everyday life. In this study, based on a literature review, the IGT total net scores and the net scores for each block of the IGT have been assessed.

While statistical analyses showed no significant difference in IGT performances according to age and level of education, gender-related differences were found between some parameters. In the first administration of the IGT, no significant difference was found between gender groups regarding IGT total net score. However, in the second run of the IGT, the men's total net score was found to be significantly higher than the women's. This finding is consistent with the literature. Some studies try to explain this situation by suggesting that for women to show a performance similar to that of men, the IGT should be administered with an additional 40-60 trials (21). In other words, they propose that women need a greater number of attempts until they begin to choose from advantageous decks. Another explanation suggests that the difference between women and men in the IGT performance results from the men's sensitivity against penalties in the context of earning. A PET study devoted to this issue showed that in men, during the IGT the right and left orbitofrontal cortex were activated, whereas in women activity was seen in a small area of the medial orbitofrontal cortex. It has been reported that the orbitofrontal cortex plays an important role in learning the reward/penalty values of the decks at the beginning of the IGT; during the IGT performance, the right dorsolateral prefrontal cortex was active in men, while this activity was not observed in women (22). The dorsolateral prefrontal cortex is part of a system inhibiting or repressing risk taking, and this area is activated in men during IGT. In the standard 100-attempt IGT version, when men reach the risk-taking level, they are drawn towards the advantageous decks, while women at that level continue choosing from the disadvantageous decks and thus keep taking risks even in the repeat administration of the IGT (21). fMRI studies undertaken to explain the gender difference found that the right lateral orbitofrontal cortex is related to decision-making and punishment, and during KGT, this area shows more activity in men than in women (22).

Given that decision-making behavior is independent from executive functions and patients with decision-making disorder do not show any anomaly in these tests, IGT performance has been compared to performance in Tower of London Test, Wisconsin Card Sorting Test, and Stroop Test. In this study, no statistically significant correlation has been found between the scores from executive function tests and IGT performance. This result is consistent with other studies in the literature assessing this relation. A meta-analysis by Toplak et al. (23) showed that most studies examining the relation between executive functions and decision-making behavior did not find such a relation. The same paper determined that four out of 25 studies assessing the relation between working memory and IGT found statistically significant results, and 24 out of a total of 115 correlation analyses found statistically significant results between executive functions and IGT. Decision-making requires the simultaneous coordination of more than one cognitive process, which suggests that executive functions are effective in

decision-making behavior. However, there are also data suggesting that relations between decision-making behavior and executive functions are different in risky and uncertain situations (1). It has been indicated that there is a stronger correlation of executive functions with performance in tests measuring decision-making behavior in risk situations than with the IGT performance, and that this is an indication that the former play a more effective role in situations requiring decision-making under the distinctive rules of DLPFC rather than in decision-making in situations of uncertainty. High scores in executive function tests have been found related with more advantageous choices in decision-making in risk situations (24). At the same time, there are studies showing a positive correlation between IGT performance and executive functions, and this may prove that the DLPFC plays a role in decision-making under uncertainty. The correlation also explains how after learning the rules regarding the advantageous and disadvantageous decks in the IGT, selections are no longer uncertain but turn into risky choices (25).

Looking at the normative data obtained from this study, it can be said that a large number of healthy participants showed a weak performance in the IGT. Bechara et al. (26) emphasized this point in a study, reporting that in a healthy population, 37% reached a net score lower than 10, and although most showed a normal performance, a number performed similar to patients with a ventromedial lesion. These participants characterized themselves as persons who take risks, seek excitement, or gamble in their everyday lives. Risk-taking is not related to a weakness in reasoning or decision-making behavior (27).

In the administrations of IGT1 and IGT2, the second run after the first showed that participants increased their performance through the effect of learning. In the first studies using IGT, especially patients with a VMPC lesion were administered the test again, but they showed the same unsuccessful performance in the second run as in the first, whereas healthy participants increased the number of selections from the advantageous decks in the repeat administration (8). In our study, participants increased their net score in the first administration for each block during the ongoing test, and in the second run, too, they continued to show a successful performance as the test progressed, choosing cards from the advantageous decks. Nevertheless, a number of participants had difficulties understanding which decks in the IGT were advantageous and which disadvantageous. At the beginning of the test, the decks display uncertainty, and which of them are advantageous or disadvantageous can only be understood in the longer run, thus requiring the participants to choose from each deck initially. Therefore, participants learn the frequency and amounts of reward/penalty in the longer run, and from that point on are able to refer to certain decks as risky (1,25). Based on this information, it can be explained that the reason why some healthy participants show a weak performance, achieving a low net score, might be that 100 trials are insufficient for them to learn which of the decks are disadvantageous and which are advantageous. The increase of participants' points in the second administration of the IGT in our study may also be an indicator supporting this assumption. Thus, while Bechara et al. (26) found an average net score of above 20 in healthy adults, in our study the net score average only reached this number in the second administration.

The small study sample group size is a limitation of this research; therefore, the correlational findings of this study need to be backed up with future studies. The comprehensive assessment of the correlation between decision-making behavior, demographic variables, and executive functions needs to be continued with larger sample groups.

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