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Development and Validation of a Computer-based Decision-Making Task (CDMT) to Measure Decision-Making

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Abstract

Background: Decision-making and its processes are the most important and most advanced levels of human cognitive abilities.
Objectives: This study aimed to develop and validate a task-based decision-making tool.
Methods: After constructing the computer-based decision-making task, 232 individuals with high and low impulse disorders were selected using cluster analysis based on the scores of impulsivity and sensation seeking. In the next step, the task-based decision-making tool was performed individually on the participants. In order to determine the psychometric properties of the task-based decision-making tool, the validity of this tool was investigated by comparing the groups with high and low impulse disorders in the dimensions of decision-making, and criterion validity was investigated with impulsivity and sensation seeking scale, self-responsibility, and decision-making styles.
Results: The results of the comparison of individuals with impulse disorder represented the optimal discriminant validity of the task-based decision-making tool. The criterion validity with other measures indicated the good convergence and divergence validity of the tool.
Conclusions: Overall, the findings suggested the task-based decision-making tool had good psychometric properties to be used in studies of assessing the overall decision-making.

Keywords: Decision Making, Impulsive Behavior, Psychometrics

1. Background

Decision-making is a process in which, all options available for the selection are examined and eliminated one after the other. This process will continue as long as an option remains and decision-making occurs by selecting a final option (1). With this description, it appears that the deciding process is simple, but it is actually one of the most sophisticated and sometimes the most difficult issues that individuals encounter with; this is because decision-making is sometimes a choice between conflicting values and the consequences of a choice and is so important and unpredictable (2).

Thus, the decision-making refers to the process of preference formation, selection, and implementation of actions and evaluating consequences (3). If we accept that a human being is a selective creature, we clearly understand that the mind is analyzing the options and choosing and making decisions at any given moment. Understanding how people make judgments and decisions is so important that explains why studying it has become common in many fields (4), and why a lot of attention has been attracted from neurologists, neuropsychologists (5-7), and psychiatrists (8). In particular, the function of decision-making has become an important research in the field of neuropsychology, cognitive psychology, neuroscience, and economy in recent years (8).

Over the past decades, although increasing attention has been attracted to the investigation of neural correlates of decision-making and impaired decision-making ability in healthy subjects and patients with brain damage or dysfunction with the use of neuropsychology and neural imaging techniques, some important questions are still unanswered. For example, different patient groups in decision-making have deficiencies and sensitivities while coordination of such defects is unknown. More importantly, there are still some debates about the different types of decisions and decision-making situations (9). Individual differences in decision-making strategy for a long time have been a matter of interest among psychologists, as well as the tendency to use reasoning rather than intuition (10). Hence, developing new decision-making assessment

and performance-based tools has provided an approach in assessing "decision-making authority" or "the ability of decision-making in the real world" (11).

In general, most studies have assessed the decision making under two types of situations: deciding under ambiguous conditions, which is measured through tests such as Iowa gambling task (IGT), and deciding under risky conditions, which is measured through the Cambridge gambling test and GDT tests, Balloon tests, and gambling test (12-14), which include the tools designed to evaluate risky decisions. In addition, the decision-making has been studied in animal studies using a delayed reward paradigm where the animals make a distinction between small and immediate reward and a larger and delayed reward (15). Moreover, numerous questionnaires have been prepared, among which Zuckerman, Eysenck, Barrett and Dickman questionnaires can be noted.

Both types of neurological and questionnaire tools have advantages and limitations, which make the existence of another type of objective measurement tools in this area necessary. Despite the ability to consciously examine the status of the person,

questionnaires can be affected by the subjects' bias. In other words, since, according to Damasio (7), many of the decision-making mechanisms are not working consciously, the questionnaire that requires the person's conscious knowledge of the behavior cannot be a good tool to assess decision-making.

Overall, the use of questionnaires on examining the behavior and inclinations is always faced with three problems: first, the reliability is questionable, especially in the study of social behavior; second, in many cases, people have not matured consciousness of their behavior; and third, the questionnaires generally measure the risk-seeking behavior or history of this type of behavior and do not provide the possibility for placing a person in the situation of actual behavior. Manual tests and computerized decision-making functions have been expanded in the areas of cognitive neuroscience, psychology, and psychiatry, but as mentioned before, they are often limited to risky decision making. Some of these tests as previously mentioned, are Iowa gambling test and Rogers's decision-making test, which measure individual risky deciding strategies under uncertainty. The impulsivity tests include signal stop task and go/no-go task. Although the above-mentioned tests measure different aspects of risky behaviors, such as cognitive and motor impulsivity, time and delay role in decision-making and the frequency and amount of reward and punishment in the risky performance, they do not address, in particular, the general aspects of daily deciding that often require paying attention to risk-taking and risk-seeking.

Although many of the decisions made outside of the uncertainty and risky situations do not include reward and punishment, there is no assessment tool to be used for this type of decision-making. Therefore, addressing a tool to assess decision-making as an objective and task-based behavior and to look at its processes is important to resolve some of the ambiguities in the identification and treatment of cognitive problems. Accordingly, the aim of the current study was to develop and validate an objective and task-based decision-making tool.

2. Objectives

Developing and validating a decision-making tool, which includes decision-making speed, decision-making accuracy and decision-making error.

3. Materials and Methods

3.1. Ethical Provisions

All procedures performed in the study, involving human participants, were in accordance with the ethical standards of the institutional and/or national research committees and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

3.2. Participants and Procedure

Due to not manipulating the variables and comparing the groups, this study belongs to Ex post facto research (causal-comparative). On the other hand, according to the calculation of the validity of the decision-making tool using other scales, it belongs to descriptive-correlation research. The participants were 232 students (with an average age of 22.7 and a standard deviation of 2.66) who were selected through available sampling in 2017. The sample size was calculated based on Hu and Bentler proposed an approach in this way. Inclusion criteria for participants were being aged 18 or older and not yet being diagnosed with the medical condition. Participants with a psychotic disorder, problems with substance, suicide attempts, poor language skills, or cognitive impairment were excluded.

All participants were informed fully about the aims of the research, and formal consent was obtained prior to commencing data collection. In the next step, the participants were invited to the psychology laboratory to measure the performance in decision-making task, impulsivity, and sensation seeking scale, self-responsibility, and decision-making styles. Then, the researcher explained the study procedure to the participants. It should be mentioned that the participants were studied individually. In the next step, each participant was placed in front of a

computer and then guided by the examiner to complete the decision making task. After the participants left this step, impulsive sensation seeking questionnaire, personal responsibility scale, and decision making styles questionnaire were distributed to them to respond. After collecting data, cluster analysis was conducted based on the scores of impulsivity and sensation seeking, the scores of the two subscales were calculated, and the participants were distributed in three clusters. They were categorized in three groups of high impulsivity and sensation seeking, low impulsivity and sensation seeking, and moderate impulsivity and sensation seeking. Finally, the three groups of the participants were compared based on decision-making components. In this way, the research data were collected from the sample for three months.

3.3. Measures

3.3.1. Azad-Amiri Computer-Based Decision-Making Task

This tool was developed to evaluate the decision-making under reward seeking, ambiguity, and risk-taking situation. In this way, each person was exposed to 90 decision-making situations, containing 30 decisions in any of the reward-seeking, ambiguity, and risk-taking situations. Each option had the number of coins or amount of time and by selecting an option, the rewards and the time could be obtained. The amount of time that a person needed for carrying out the task was free, but the participants were said that they should try to save the most time and coins they can and avoid negative time. This task measures the following components: speed of decision making (in reward-seeking, ambiguity, and risk-taking), confidence to decision making (in reward-seeking, ambiguity, and risk-taking), reward-seeking, avoiding ambiguity, and risk taking. Speed is defined as: "The amount of time a person takes to press the button"; Confidence is defined as: "The number of times that a person returns to the previous elections and changes their selection;" Reward-seeking is defined as: " How much a person chooses a higher reward option (including coins and time);" Avoiding ambiguity is defined as: "Selecting an option for the faster exit from this situation, choosing in less than 3 seconds (high), less than 6 seconds (intermediate), and less than 10 seconds (low); Risk-taking is defined as: "How much a person chooses options with small probability of winning (%25) and the high probability of punishment (%75 loss coins and time), but if they win, rewards are high (including coins and time)". The minimum time required to complete this task is 1.5 minutes and the maximum time is free. In order to measure the content validity of the decision-making task, the experts from the field of cognitive science in Iran, the United States, and the United Kingdom were consulted within 105 days, and after applying the points, the tool was finally approved. The process of getting comments and doing them repeatedly was repeated 4 times until the final improvement.

3.3.2. Impulsive Sensation Seeking

This scale consists of 19 items and two subscales of impulsivity and sensation seeking. The results indicated a high internal consistency of this scale with the alpha coefficient of 0.83. The predictive validity in individuals with the abuse of tobacco, alcohol, and cannabis has been favorable. The factor structure of this scale has supported its two-factor structure (16). The psychometric properties of Impulsive Sensation Seeking in an Iranian population showed its good psychometric properties. The Cronbach's alpha coefficients for the two subscales of impulsivity and sensation seeking were 0.87 and 0.86, respectively, and factor analysis supported the factorial structure of the questionnaire. In this study, the Cronbach's alpha coefficient was 0.74 and 0.76, respectively.

3.3.3. Personal Responsibility Scale

This scale consists of 15 items and three subscales of personal accountability, behavioral and emotional control and cognitive control. The results indicated the high internal consistency of this scale, and the three subscales' alpha coefficients were 0.81, 0.81, and 0.71 (17). The psychometric properties of personal responsibility scale in Iranian society indicated its desirable characteristics. The Cronbach's alpha coefficients for the three subscales of personal accountability, behavioral and emotional control, and cognitive control were 0.89, 0.84, and 0.94, respectively. The retest coefficients were reported as 0.68, 0.66, and 0.63, which showed the desired reliability of this scale. In this study, the Cronbach's alpha coefficients for the three subscales were 0.68, 0.71, and 0.69, respectively.

3.3.4. Decision-Making Styles Questionnaire

This questionnaire measures the following five different styles of decision-making: rational, intuitive, dependent, avoidant, and immediate (18). The questionnaire has 25 questions (five questions for each dimension). The reliability and validity of the questionnaire to measure decision-making styles have been examined in various studies and good results have been reported. The reliability of the questionnaire by means of Cronbach's alpha has been reported from 0.62 to 0.87 for different styles (19). The good psychometric properties of this questionnaire have been reported in Iran. The reliability of this questionnaire was calculated in two ways: test-retest and Cronbach's alpha. The test-retest coefficient was reported as 0.76. The

Cronbach's alpha coefficient for this questionnaire was obtained as 0.88. The results showed that the correlation coefficients between the subscales were -0.47 to 0.59 and concurrent validity with other measures was obtained as 0.51 to 0.53 (20). In this study, the Cronbach's alpha coefficient for the total questionnaire was obtained as 0.68.

3.3.5. Data Analytic Strategy

SPSS version 22 (SPSS IBM, New York) was used to perform statistical analyses. Bivariate correlations were assessed to examine the convergent validity. Then, the obtained data were analyzed using multivariate analysis of variance, ANOVA, and post hoc test.

4. Results

Of the total participants, 176 were at least undergraduate students, 56 people had diploma degrees, 152 were single, and 80 were married; 88 of them were men and 144 were women. The participants mean age and standard deviation were 22.7 and 2.66, respectively. Descriptive statistics of the study variables are presented in Table 1.

The validity was examined in two ways: the criterion validity [conducting simultaneously with the impulsive sensation seeking, personal responsibility, decision-making styles, and the correlation between subscales].

The pattern of correlation coefficients between the subscales with impulsive sensation seeking, personal responsibility, and decision-making styles in Table 2 indicates the concurrent criterion validity of the Computer-based decision-making Task in assessing decisions.

Multivariate analysis of variance was used to compare the groups in decision-making aspects. The result of M box test showed that the assumption of the similarity of dependent variables' variance-covariance of the matrix was met and multivariate analysis of variance could be applied. The results of multivariate tests of Wilks' lambda ($F = 17.90$, $P < 0.001$) represented the difference between the groups in at least one dimension of decision-making. Considering the significance of group differences, one-way analysis of variance and post hoc test were used to determine in which groups and at which levels of variables the differences are, and the results are shown in Table 3.

According to the results of Table 3, it can be said that the comparison of the three groups represented significant differences in some aspects of decision-making. The distinction performances of individuals with high and low impulsivity in decision-making task components reflect the convergent and divergent validity of the tool. The individuals with high impulse disorder had higher decision making speed and reward-seeking (reversed scoring) in decision making under the reward-seeking situation ($P < 0.05$). The individuals with high impulse disorder had higher decision making speed and confidence and lower avoidance of ambiguity (reversed scoring) in decision making under ambiguity ($P < 0.05$). The individuals with high impulse disorder had higher risk-taking (reversed scoring) and lower confidence in decision making under the risk-taking situation ($P < 0.05$).

5. Discussion

The aim of this study was to develop and validate a task-based decision-making tool through discriminant validity analysis in subjects with high and low impulse disorders and concurrent validity with the dimensions of impulsivity and sensation seeking, accountability, and decision-making styles. Accordingly, measuring the cognitive decision-making components including the speed of decision making (in reward-seeking, ambiguity, and risk-taking situations), confidence to decision making (in reward-seeking, ambiguity, and risk-taking situations), reward-seeking, avoiding ambiguity, and risk-taking was included in this tool.

The results of the comparison of measuring the cognitive component of decision-making in individuals with high impulse disorder and individuals with low impulse disorder and control group reflected the ability of this tool to distinguish between these groups. On the other hand, in order to further validate the findings, convergence and divergence validity of decision-making components including the speed of decision making, confidence to decision making, reward-seeking, avoidance of ambiguity, and risk-taking with impulsivity and sensation seeking, personal accountability and decision-making styles were comprehensively evaluated. Studies on neurological problem patients demonstrated that the ability to make good decisions in real life is dependent on the integration of the orbitofrontal cortex (OFC) with its associated circuits (21-23). Several studies using the Iowa-gambling test indicated impaired decision making in patients with psychiatric disorders such as alcohol abuse, borderline personality disorder, suicidal behaviors, and lateral-medial prefrontal cortex abnormalities in neuroimaging studies (21, 23). Given that people with impulse disorder are impaired in brain functions associated with the prefrontal lobe and orbitofrontal cortex, the present research findings are consistent with the results of studies that indicated decision-making functions defects in individuals with an impairment in these brain regions, such as patients with ventral prefrontal and lateral orbitofrontal cortex damages (24, 25), patients with frontal lobe dysfunction as a result of addiction (26-28), patients with Parkinson's disease

Table 1. Descriptive Statistics of the Study Variables

Group	Reward Seeking			Ambiguity			Risk-Taking		
	Speed	Reward-Seeking	Confidence	Speed	Avoidance of Ambiguity	Confidence	Speed	Risk-Taking	Confidence
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
High	104664.28 (16594.83)	58.00 (0.00)	0.00 (0.00)	221270.57 (134540.20)	22.71 (9.29)	0.00 (0.00)	55728.14 (22486.77)	66.00 (16.01)	0.14 (0.07)
Low	80094.46 (39231.82)	58.00 (0.00)	0.119 (0.13)	184619.23 (104262.17)	25.46 (6.49)	0.15 (0.06)	62359.15 (32855.58)	57.00 (13.37)	0.76 (0.16)
Control	60743.88 (35745.20)	57.77 (0.63)	0.277 (0.16)	170325.66 (96807.64)	27.11 (4.59)	0.11 (0.03)	52611.11 (27431.28)	53.11 (13.82)	0.00 (0.00)
Total	80019.75 (37458.38)	57.93 (0.36)	0.172 (0.03)	189030.17 (110879.90)	25.31 (6.93)	0.103 (0.30)	57733.31 (29074.58)	57.96 (17.87)	0.69 (0.05)

Table 2. Correlation Coefficients Between Study Variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Speed	1																		
Reward-seeking	0.27[a]	1																	
Confidence	0.11	0.02	1																
Speed	0.56[a]	0.20[a]	-0.07	1															
Avoid of ambiguity	-0.53[a]	-0.13	0.07	-0.96[a]	1														
Confidence	0.21[a]	-0.56[a]	-0.05	-0.09	0.05	1													
Speed	0.69[a]	0.21[a]	0.06	0.65[a]	-0.64[a]	0.20[a]	1												
Risk taking	0.28[a]	0.18[a]	-0.05	0.63[a]	-0.63[a]	-0.26[a]	0.35[a]	1											
Confidence	-0.12	0.05	-0.04	-0.15[b]	0.16[b]	-0.09	-0.18[a]	-0.11	1										
Impulsivity	0.27[a]	-0.07	-0.02	0.11	-0.12	-0.16[b]	-0.11	0.15[b]	0.10	1									
Sensation Seeking	0.12	-.029[a]	-0.05	-0.14[b]	0.21[a]	0.06	-0.08	-0.25[a]	0.15[b]	0.46[a]	1								
Personal accountability	-0.05	-0.04	-0.04	0.20[a]	-0.17[a]	0.04	-0.10	0.14[b]	0.10	0.17[a]	-.013	1							
Behavioral/emotional control	0.02	-0.02	0.11	0.01	0.01	-0.24[a]	0.17[b]	-0.12	-0.17[a]	-0.03	0.23[a]	-0.63[a]	1						
Cognitive control	-0.16[b]	-0.08	-0.10	0.09	-0.02	0.22[a]	-0.09	0.10	0.21[a]	0.09	-0.13	0.73[a]	-0.53[a]	1					
Rational	-0.12	-0.20[a]	-0.01	-0.21[a]	0.11	0.10	-0.14[b]	-0.25[a]	0.02	-0.03	0.06	0.09	-0.08	-0.20[a]	1				
Intuitive	0.24[a]	-0.07	-0.14[b]	0.31[a]	-0.27[a]	0.16[b]	0.10	-0.08	0.10	0.07	0.10	0.07	-0.13[b]	-0.05	0.20[a]	1			
Dependent	-0.17[a]	0.35[a]	-0.03	-0.20[a]	0.19[a]	-0.21[a]	0.04	-0.13	-0.40[a]	-0.10	-0.08	-0.07	0.22[a]	-0.15[b]	0.15[b]	-0.08	1		
Avoidant	0.33[a]	0.05	-0.14[b]	0.29[a]	-0.33[a]	0.12	0.41[a]	0.05	-0.07	0.15[b]	0.18[a]	-0.52[a]	0.45[a]	-0.33[a]	-0.06	0.20[a]	0.18[a]	1	
Immediate	-0.17[a]	-0.10	-0.05	-0.19[a]	0.17[a]	0.13[b]	-0.07	-0.30[a]	-0.39[a]	0.04	0.12	-0.36[a]	0.41[a]	-0.02	-0.25[a]	-0.08	0.35[a]	0.38[a]	1

[a] P< 0/01
[b] P< 0/05

and Huntington (29, 30), Schizophrenia (31), and obsessive-compulsive disorder (32).

Neural imaging studies have found that addicts compared to healthy adults during the risk-taking test have the changes in brain metabolism in the temporal and frontal regions (including the orbitofrontal cortex (33, 34). One of the most important cognitive deficits associated with addiction is defects in the decision-making process, particularly risky decisions, in addicts (35). All these findings suggest the critical role of the orbitofrontal cortex function in the decision-making process (36). In the anatomical aspect, there is evidence showing that different regions of the frontal exclusively contribute to decision-making processes. It seems that orbitofrontal cortex (OFC) is associated with incentive taking situations (37-39), estimation based on the best guess (2, 3), and emotional experience associated with gains and losses. This ability represents the role of OFC in response to environmental consequences and adaptive behavior to cope with various situations.

5.1. Conclusion

The current study was the first attempt to develop a tool to measure the dimensions of decision-making in reward-seeking, ambiguity, and risk-taking situations. The

Table 3. The Results of the Three Groups' One-Way Analysis Of Variance and Post Hoc Test in Decision-Making

Dependent Variable	F	(η2) Eta	Source of Comparison	Means' Differences	Standard Error
			low-control	19350.57[a]	5185.24
			low-high	-24569.82[a]	5605.89
Speed	26.56	0.19	control-high	-43920.39[a]	6026.16
			low-control	0.22[a]	0.05
			low-high	0.00	0.05
Reward-seeking	9.87	0.08	control-high	-0.22[a]	0.06
			low-control	-0.008	0.02
			low-high	0.019	0.02
Confidence	0.73	0.006	control-high	0.027	0.02
			low-control	14293.56	16776.89
			low-high	-36651.34	18137.91
Speed	3.56	0.03	control-high	-50944.90[c]	19497.67
			low-control	-1.64	1.03
			low-high	2.74[c]	1.11
Avoidance of ambiguity	6.72	0.06	control-high	4.39[a]	1.20
			low-control	0.04	0.04
			low-high	0.15[b]	0.04
Confidence	4.81	0.04	control-high	0.11[c]	0.05
			low-control	9748.04[c]	4417.04
			low-high	6631.01	4475.37
Speed	2.61	0.02	control-high	-3117.03	5133.37
			low-control	3.88	2.16
			low-high	-9.00[a]	2.33
Risk-taking	13.61	0.11	control-high	-12.88[a]	2.51
			low-control	0.07	0.03
			low-high	-0.06	0.04
Confidence	5.26	0.04	control-high	-0.14[b]	0.04

[a] $P < 0.001$
[b] $P < 0.01$
[c] $P < 0.05$

results showed that the computer-based decision making task can be used to assess decision-making alongside other tools including Balloon Analogue Risk Task, Cambridge and Iowa Gambling Test, and various impulsivity questionnaires, with the difference that the tool developed in this study could also be used to assess decision-making in normal situations (reward seeking), as well as ambiguity and risk-taking situations. However, it should be noted that this study was performed on normal sample; hence, in order to increase the validity of decision-making tool, studying the validity of the tool on different populations is recommended, especially among patients with brain injuries, substance abuse, and mental disorders such as obsessive-compulsive individuals who have difficulties in making decisions.

Footnotes

Authors' Contribution: Sohrab Amiri and Esfandiar Azadmarzabadi designed and layout the Project idea helped to write and analyze the results. All authors studied and approved the manuscript.

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