

# Normal Decision-Making and Executive Functions in Alcohol Dependent Individuals

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## ABSTRACT

Normal decision-making and executive functions in alcohol dependent individuals

**Objective:** Decision-making processes have become a principal target of study among addiction researchers. However, studies are often hampered by two significant methodological challenges: multi-substance dependence and comorbid conditions, which are independently associated with neurocognitive impairments. The purpose of this study was to compare alcohol dependent subjects without any comorbidity, with controls on a measure of decision-making and executive functions and to examine the interrelationship among these measures.

**Methods:** We compared 30 alcohol-dependent (AD) male patients with 30 matched male healthy controls regarding their performances on the Iowa Gambling Task, Wisconsin Card Sorting Test, Stroop Test, Auditory Consonant Trigram Test and the Category Naming Test.

**Results:** The AD group was not significantly more impaired compared to controls on any test. Only working memory scores were associated with decision-making scores in the total group.

**Conclusion:** The results suggest that our sample of pure AD do not have global deficits in decision-making as measured by the IGT and that their poor decisions regarding their alcohol consumption are limited to drinking.

**Key words:** Decision making, alcohol dependence, executive functions, Iowa Gambling Task

## ÖZET

Alkol bağımlılarında normal karar verme ve yürütücü işlevler

**Amaç:** Karar verme (KV) süreci, bağımlılık alanındaki çalışmaların ana hedefi haline gelmiştir. Ancak, bağımlılarda sık görülen yüksek miktarda çoklu madde kullanımı ve psikiyatrik eşitani birlikteliği, KV çalışmalarının iki önemli yöntemsel kısıtlılığını oluşturmaktadır. Bu çalışmanın amacı, birinci ve ikinci ekseninde herhangi bir psikopatolojisi olmayan alkol bağımlılarında (AB) ve kontrol grubunda KV ve yürütücü işlevlerin karşılaştırılması ve KV ile yürütücü işlevler arasındaki ilişkinin araştırılmasıdır.

**Yöntem:** Çalışmada 30 alkol bağımlısı erkek hasta ve 30 eşleştirilmiş sağlıklı erkek kontrol grubunun Iowa Kumar Testi (IKT), Wisconsin Kart Eşleme Testi, Stroop Testi, Sözel Acıklık Testi ve İşitsel Üçlü Sessiz Harf Sıralaması Testi puanları karşılaştırılmıştır.

**Bulgular:** Alkol bağımlısı grup ile sağlıklı kontrol grubu arasında, yapılan hiçbir testte herhangi bir anlamlı fark saptanmamıştır. Toplam grupta sadece işleyen bellek puanlarıyla KV arasında ilişki saptanmıştır.

**Sonuç:** Sonuçlarımız, 'saf AB'de IKT ile ölçülen KV'deki bozulmanın sadece alkol kullanımıyla sınırlı olduğunu ve genel bir bozulma olmadığını düşündürmektedir.

**Anahtar kelimeler:** Karar verme, alkol bağımlılığı, yürütücü işlevler, Iowa Kumar Testi

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Date of receipt / Geliş tarihi:  
May 8, 2012 / 8 Mayıs 2012

Date of acceptance / Kabul tarihi:  
July 1, 2012 / 1 Temmuz 2012

## INTRODUCTION

Decision making (DM) is a cognitive process defined as to balance between short-term and long-term consequences of our choices (1). Impairments in DM is described as difficulties in learning from previous mistakes and repeated engagement in decision that lead to negative consequences in the future by an individual (2). Although several tests have been

developed later, Iowa Gambling Task (IGT) is the most commonly used DM test (3). The task was initially developed for patients with ventromedial prefrontal cortex (VMPFC) damage. It has been observed that, although these patients did not have any cognitive impairments other than DM impairment, they made decisions that led to negative consequences in their social lives and that they made very little changes in their behavior in spite of those negative consequences.

Researchers indicate that IGT simulates real life decision making processes since it involves reward, punishment and uncertainty. It has also been reported that IGT results are in parallel with the real life problems that patients with VMPFC lesions experience (4).

DM behavior has been investigated in several studies in individuals with substance dependence since the definition of DM is similar to the definition of dependence in terms of “using the substance in spite of negative consequences”. Conflicting results have been derived from these studies. There have been studies which reported impaired DM in subjects with alcohol (5), cannabis (6), MDMA (ecstasy) (7), heroin and cocaine (8) along with studies which reported no impairments in subjects with alcohol dependence (AD) (9), AD without antisocial personality disorder (ASPD) (10), individuals with cannabis (11) and cocaine dependence (12), when compared with the control groups. Still, it has also been reported that DM is impaired only in some of the subjects with dependence (13).

Differences in study results may be due to methodological limitations. There are two important limitations in subjects with dependence. The first limitation is that most of the subjects have multi-substance dependence. The subjects are grouped according to the most commonly abused substance and multi-substance abuse is disregarded. There are studies which showed that decision making is more impaired in multi-substance abusers than single substance abusers (14). Studies also revealed that impairment is more severe in heroin, cocaine or MDMA abusers than alcohol or cannabis abusers (11,15,16). Another limitation of the studies is the lack of complete exclusion of comorbid first and second axis psychiatric disorders. Impaired DM has been reported in several psychiatric disorders. Impaired DM has been reported in subjects with pathological gambling (17), schizophrenia (18), obsessive-compulsive disorder (19), attention-deficit hyperactivity disorder (20), borderline personality disorder (21), ASPD (5), anorexia nervosa (22), major depression (23), and manic episode (24). Therefore, presence of frequent comorbid psychiatric disorders, particularly personality disorders in subjects with

dependence brings to mind whether the reported impairments in DM are due to comorbidity or dependence itself (25). Effects of personality disorder, particularly ASPD comorbidity on DM in subjects with alcohol dependence has been investigated in the literature. It has been reported that DM impairment decreases significantly or disappears when the antisocial personality features or ASPD is excluded (26).

There are several publications on impaired executive functions in AD (27,28). However, generally these studies have been conducted in the first month after cessation of alcohol use. Currently, it has been suggested that impairment due to alcohol may be partly or totally reversible in the long-term (29).

There are conflicting studies on the relationship between DM and executive functions. Early studies on the subject reported that DM and executive functions were independent processes. While executive functions are associated with dorsolateral prefrontal cortex (DLPFC), DM is associated with VMPFC (30). Studies reporting relationship between DM and executive functions have been published later (31).

The advantage of Turkey on dependence studies is that there are groups of subjects with single substance abuse, particularly alcohol and cannabis. Therefore, possible effects of multi-substance abuse on the studies are decreased. There are no studies in the literature which investigated DM in subjects with AD who used only alcohol in their lifetime. Aim of this study is to investigate executive functions, DM, and the relationship between DM and executive functions in subjects with alcohol dependence who abused only alcohol to date and who did not have any axis I or II psychopathology, to rule out the effects of both multi-drug abuse and comorbid psychopathology. Our hypothesis were that there were no differences between “pure” AD and normal controls in terms of DM, that executive functions were impaired and that there was a correlation between DM and executive functions.

## METHOD

30 male inpatients at İzmir Atatürk Research and Training Hospital Alcohol and Drug Treatment,

Research and Training Center who were diagnosed with alcohol dependence according to DSM-IV were included in the study. Healthy controls consisted of 30 male volunteers matched for age, gender and education.

Patients who had only nicotine and alcohol abuse in their lifetime, without any current or past axis I disorder (excluding nicotine dependence, specific phobia, adjustment disorder and psychiatric disorder due to substance abuse) and without any axis II personality disorder and impulse control disorder were included in the study. Patients with amnesic disorder, brain disorders (for instance history of trauma or epilepsy resulting in unconsciousness longer than 30 minutes), severe physical disorders (cirrhosis, renal disorders, vision impairment) and who are illiterate were not included in the study. The same criteria were used for the healthy controls without any history of alcohol abuse.

Patients who accepted to participate in the study were recruited to the study between 20th to 30th days of their inpatient treatment. Structured Clinical Interview for DSM-IV Axis I Disorders/ Clinical Version (SCID-I) and Structured Clinical Interview for DSM-III-R Axis 2 Disorders were administered to patients, who were not taking additional psychotropic drugs and taking only Vitamin B complex, by DE. Minnesota Impulsive Disorders Interview (MIDI) revised form was used to determine Impulse Control Disorders (ICD). Iowa Gambling Task (IGT) was used to assess DM, Wisconsin Card Sorting Test (WCST), Stroop test, Verbal Fluency Test were used to evaluate executive functions and Auditory Consonant Trigram Test (ACTT) was used to assess working memory.

Local ethical board approval was obtained for the study. Written informed consent was obtained from all patients and controls.

## MATERIALS

**SCID-I/CV (Structured Clinical Interview for DSM-IV Axis I Disorders):** It is a diagnostic tool developed by First and colleagues (32). SCID-I was translated to Turkish and reliability/validity studies of the translation were done (33).

**SCID-II (Structured Clinical Interview for DSM-III-R Axis II Disorders):** It is a semi-structured observation tool administered by the interviewer to investigate personality disorders per DSM-III-R diagnostic criteria. Personality scale consists of 120 items and includes screening questions for personality disorders. SCID-II was developed by Spitzer and associates (34) and adapted to Turkish by Sorias and colleagues (35).

**Minnesota Impulsive Disorders Interview (MIDI):** Turkish adaptation is used to evaluate the presence of lifetime ICD. Questionnaire is a 36 items semi-structured interview. Different Impulse Control Disorders (Intermittant Explosive Disorder, Pathologic Gambling, Kleptomania, Trichotillomania, Pyromania, Compulsive Shopping, Skin Picking, Compulsive Sexual Behavior, Compulsive Exercise) are investigated in separate modules according to DSM-IV criteria (36).

**Executive Function Tests:** Tests were employed by SP in a single sitting. The tests which are used in the present study are summarised below.

**Wisconsin Card Sorting Test (WCST):** It is developed by Heaton (37). As one of the tests used to evaluate frontal cortex functions, WCST is considered particularly sensitive to dorsolateral prefrontal DLPFC cortex functions (38). Computer version is used in the study. Success depends on the comprehension of matching principle in WCST. 128 geometrically designed cards grouped into three in terms of color, form or number are used in the test. There is no time limit. Turkish adaptation study was conducted by Karakaş and associates (39). Number of perseverative errors and number of categories completed were used in the analysis.

**Stroop Test:** It is a test to evaluate the ability to ignore distracting stimuli (interference) by using reading words against naming colors (40). Only a single visual feature must be selectively processed and others must be inhibited to do the test. Smooth adaptive behavior

capacity is also important to succeed in the test. Stroop test consists of four parts: reading words printed in black, naming colored squares or points, reading color names written in a different color than the word and naming the colors of the words printed in color without reading the words. There are different versions of the test varying in colors, items, scoring and order of administration. In later years, naming colors of the words which are not color names part has been added to the test. Turkish adaptation study was conducted by Karakaş and associates (39).

**Auditory Consonant Trigram Test (ACTT):** It is a test to evaluate working memory. Total number of correctly remembered letters is used in the analysis. Validity and reliability of the Turkish form is studied (41).

**Category Naming Test:** It is the most commonly used verbal fluency test. Verbal fluency tests are useful to assess whether the individual can (and to which degree) organise his/her thoughts. These tests are associated with frontal lobe damage (42). Participants need to generate words from a category. The most commonly used categories today are animals, fruits, vegetables, drinks and food which can be bought from any marketplace. Verbal fluency is found to be impaired also in patients with schizophrenia (43).

**Iowa Gambling Task (IGT):** In the gambling task, subjects sit in front of four decks of cards labeled A, B, C, and D. Play tokens worth of 2000 TL are loaned to players. Players are told that the goal in the task is to gain as much or loose as little money as possible. The play is stopped after selection of 100 cards. Each deck includes 40 cards. While 250 TL is gained for every 10 cards selected from advantageous decks (C and D), 250 TL is lost for every 10 cards selected from disadvantageous decks (A and B). Performance in the gambling task is evaluated by net scores and the difference between number of selections from advantegous and disadvantageous decks in every 20 selections. Net score is the difference between number of selections from advantageous and disadvantageous

decks in the whole task. Total number of cards used are 100 and each 20-cards block represent a sub-block. This also corresponds to 4 learning phases. The first 20 cards (1-20) represent guess, second 20 cards (21-40) represent pre-hunch, third 20 cards (41-60) represent hunch and the fourth and fifth 20 cards (61-100) represent conceptual knowledge. Validity and reliability of the Turkish form was studied (44).

### Statistical Analysis

We used independent t test for numerical and chi-square test for categorical variables to compare sociodemographic and neuropsychological test data of the patient and the control groups. 2 (patient and control) x 5 (1-20,21-40,41-60,61-80,81-100) two-factor variance analysis was used to analyze within-group and between groups IGT data. Total score was computed by subtracting the number of cards selected from advantageous decks and from disadvantageous decks from 5 blocks consisting of 20 cards. We used Pearson correlation analysis to analyze the direction and magnitude of the association between the variables.  $p < 0.05$  was reported as statistically significant for all statistical analysis.

### RESULTS

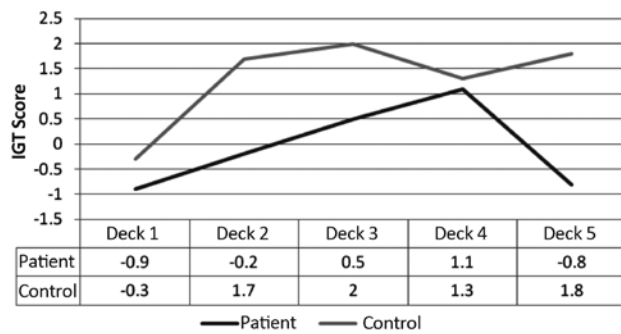
There were 30 males with alcohol dependence and 30 male controls matched for age and education in the study. All 60 subjects in the study were males. Since most of the inpatients were males, only males were included in the study. Mean age was  $48.9 \pm 5$  in the patient group and,  $48.6 \pm 5$  in the control group. The difference between the groups was not significant. When the education of the patient and control groups were examined, there were 15 (50%) subjects who were graduated from primary school, 12 subjects (40%) were graduated from high school and 3 subjects (10%) had higher education in both groups.

First use of alcohol was  $16.8 \pm 3$  years, duration of alcohol use was  $32.1 \pm 6$  years, duration of problematic use was  $12.3 \pm 10$  years and quantity of daily alcohol consumption  $17.8 \pm 5$  standard drink.

**Table 1: Comparison of executive functions of patient and control groups**

Executive Function Test	Patient Mean±SD	Control Mean±SD	t	p
WCST - category	2.67±1.70	3.63±2.20	-1.898	0.063
WCST - perseveration	29.13 ±13.16	24.60±12.47	1.369	0.176
Stroop Test - time	97.80±37.93	82.97±21.41	1.865	0.067
Stroop Test - error	2.17±3.94	0.60±1.67	2.001	0.050
Stroop test - spontaneous correction	1.83±2.01	1.17±1.31	1.556	0.667
ACTT	43.07±7.23	43.27± 5.61	-0.120	0.905
Verbal Number	20.23±4.50	19.80±2.89	0.443	0.659
Verbal Perseveration	0.60±0.89	0.53±0.57	0.344	0.732

WCST: Wisconsin Card Sorting Test, ACTT: Auditory Consonant Trigram Test, t: Student t Test, SD: Standard Deviation



**Figure 1. Change of IGT score during 100 cards in alcohol dependence and healthy control groups (each deck includes 20 cards)**

IGT: Iowa Gambling Task

There were no significant differences in executive function tests between the patient and the control groups (Table 1).

Analysis of IGT data revealed that the whole study group did not avoid the disadvantageous decks during selecting the cards ( $F=0.559$ ,  $p=0.650$ ) and that IGT net score was not statistically different between the two groups ( $F=1.519$ ,  $p=0.253$ ) (Figure 1). Total IGT score was found as  $-0.2\pm 19.5$  in the patient group and as  $6.6\pm 23.0$  in the control group. The difference was not statistically significant ( $t=-1.232$ ,  $p=0.223$ ).

In the whole sample, the association between age, executive function tests and IGT total score as well as the association between dependence variables and IGT total score in the dependent group were investigated with Pearson correlation analysis. The only significant correlation was between ACTT and IGT total score ( $r=0.332$ ,  $p=0.01$ ).

## DISCUSSION

There are three important results of our study. In the "pure" AD group, we did not find impairments first in DM and second in executive functions. The third important result is that DM and executive functions, other than working memory, were not correlated.

When the literature is examined, it can be seen that, generally, there was multi-drug abuse in AD subjects participating in the DM studies and that possible psychiatric comorbidity was only partially controlled. This makes the interpretation of the results harder. For instance, impulsivity may be higher in subjects with multi-drug abuse and impaired DM may be due to impulsivity or multi-drug abuse may impair DM by leading to more extensive brain damage or comorbid psychiatric disorders may cause impaired DM. We reached to "pure" AD for all these reasons. By this way, we thought that the possible relationship between AD and DM might be determined more definitely. As we expected, contrary to several studies in the literature, we did not find DM impairment in the AD group in our study. While the patients with alcohol dependence had impaired DM in their drinking behavior, their selections were similar to normal controls in the IGT. This finding suggests that DM in AD may be specific to drinking behavior. We think that there may be various reasons for lack of DM impairment in the AD group. First reason may be low impulsivity of the patient group. The AD patient group included in the study consisted of inpatients who did not abuse other substances other than alcohol, who did not have any axis one and two

psychiatric comorbidity, who had low antisocial features and who were middle aged or older. The relationship between impulsive personality features and DM have been shown in various studies. As emphasized in the introduction, DM impairment is decreased or is not detected at all in groups with alcohol dependence without ASPD (5,25). Besides, there are studies which reported that DM impairment is increased with higher impulsivity scores (11,45). In another study conducted with healthy individuals revealed negative correlation between high impulsivity scores with DM (46). Several studies reported association between DM and personality features in individuals who did not have psychopathology (47). DM process, which is shown to be impaired in several psychiatric disorders as well as in healthy individuals, may be a different dimension of a general personality feature, like impulsivity, rather than being associated with a single disorder like dependence. The second possible cause is that different substances may have distinct effects on DM. There are studies which reported differential effects of substances on DM and executive functions. For instance, while DM is impaired in MDMA abusers, there is no difference between cannabis addicts and control group (11). Again, while impaired DM and executive functions found in cocaine and methamphetamine abusers, there were no differences between the control group and the alcohol dependent group. Likewise, executive functions which are found to be impaired in cocaine and methamphetamine abusers are not significantly different in the alcohol dependent group when compared with the control group (15). Studies showing that abuse of distinct substances have differential effect on DM suggest that the impairment may be not the cause, but the result of dependence.

Lack of significant association between DM and executive functions other than working memory scores is consistent with the literature in general. The correlation between IGT and working memory scores is also weak ( $r=0.332$ ). Several authors state that DM is associated with VMPFC while executive functions are

associated with DLPFC and that these two are separate processes (30,48). In a meta-analysis, Toplak and associates (31) reported that in most of the studies there were no associations between decision making and executive functions, and that effect sizes were low to moderate and the confidence intervals were wide in the studies reporting significant associations. In the same study it was revealed that, out of the 25 studies which investigated the correlation of working memory and IGT, only four reported statistically significant results, and that out of the 115 analysis of correlation between IGT and executive functions, only twenty four were significant.

Another finding is that executive functions were not different in alcohol addicts and normal controls. Although executive functions has been reported to be impaired in individuals with alcohol dependence in the literature, there are other studies which did not find the control group significantly different (15,49). It has also been reported that in half of the AD there were no cognitive impairment and that the impairments found were mild and tended to be temporary in the year following abstinence (50). Besides, different substances may lead to various levels of cognitive impairment. For instance, chronic cocaine abuse is reported to lead to more severe impairment of executive functions when compared with alcohol abuse (51). In our study, lack of significant difference with the control group might be due to inclusion of inpatients who did not have any comorbid psychiatric diagnosis and who may be functionally better than AD subjects who were not hospitalized and who did not seek treatment.

The most important limitation of the study was small sample size. This limits the generalization of the results to all individuals with alcohol dependence. Inclusion of only patients who sought treatment limits the generalizability of the results to patients who did not apply for treatment. In spite of these limitations, our results suggest that in AD individuals without comorbidity, DM impairment evaluated by IGT is limited to alcohol use and that there was no general impairment.

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