SM Preventive Medicine and Public Health ISSN: 2576-4004

Original Article

The Profiles of Time Perception and Inter-Temporal Choice in Alcohol-Dependent Patients with Smoking Behavior and the Effect on Re-Drinking

Xiaoyuan Han[1#], Yangyang Xu[2#], and Xu Chen[3*]

[1]Faculty of Psychology, Southwest University, China

[2]Baoshan Foreign Language School affiliated to Shanghai University, China

[3]Department of Psychiatry, Shandong University, China

Abstract

Objective: This study explored time perception and intertemporal decision-making profiles in Alcohol Dependent (AD) patients during chronic withdrawal, and their effect on re-drinking, including tobacco-use influence.

Methods: Using convenience sampling, participants included AD patients with light smoking (LS, n=22), AD patients with heavy smoking (HS, n=42), and healthy controls (HC, n=42). Withdrawal severity was assessed using CIWA-Ar. Time perception was measured using Time Reproduction (TRT) and Time Discrimination (TDT) tasks; intertemporal choice was assessed via a Delayed Discounting Task (DDT).

Results: AD patients showed significantly higher Drr values (TRT) for 1s/2s intervals and higher Coefficient of Variation (CV) values across all six intervals compared to HC ($P<0.05$). The AD group had a lower b value (TDT) than HC ($P<0.01$). Significantly higher delay discounting rates (k values) were found in the AD group versus HC for both small (SS=10) and large rewards (SS=100) ($P<0.05$). Critically, the HS subgroup had higher k values than the LS subgroup ($P<0.01$). The intertemporal choice index (k) was identified as a risk factor for alcohol re-drinking (OR=1.383, $P<0.05$).

Conclusion: AD patients exhibit significant biases in time perception and intertemporal choice. Heavy smoking AD patients show a particularly pronounced intertemporal decision-making bias. Higher delay discounting (k) may be a risk factor for re-drinking.

Keywords: Alcohol dependence; Smoking behavior; Time perception; Intertemporal decision-making; Discounting delay; Re-drinking.

INTRODUCTION

According to the World Health Organization's Global Report on Alcohol and Health (2018), the detrimental use of alcohol is responsible for approximately 3 million fatalities globally each year, accounting for 5.3% of all deaths, and contributes to over 5% of the overall disease burden [1]. It is estimated that 237 million adult men (8.6%) and 46 million adult women (1.7%) worldwide are currently affected by alcohol dependence (AD). The harmful consumption of alcohol is recognized as one of the primary risk factors for mortality among men aged 15 to 59 years. Furthermore, the incidence of alcohol-related diseases is notably higher in low- and middle-income developing nations compared to developed countries. In China, the average annual alcohol consumption rose from 4.1 liters in 2005 to 7.2 liters in 2016, representing a 76% increase, while the lifetime abstinence rate decreased from 50.9% in 2005 to 42.1% in 2016 [2]. Additionally, research indicates that over 40% of drinkers have reported an increased desire to consume alcohol in the context of the COVID-19 pandemic, with more than 20% of drinkers indicating a rise in their weekly alcohol intake [3]. As a significant public stressor, the pandemic has disrupted the normal routines of many individuals, leading drinkers to often resort to alcohol consumption as a means of coping with their altered circumstances.

Hospitalized individuals often exhibit a pronounced desire for cigarettes during periods of chronic withdrawal, with a notable prevalence of concurrent tobacco and alcohol use, which correlates with an increased risk of various health complications. The treatment of alcohol dependence can be categorized into two distinct phases: acute withdrawal and chronic withdrawal. Acute withdrawal is primarily managed through pharmacological interventions aimed at alleviating severe withdrawal symptoms, whereas chronic withdrawal represents a more advanced treatment phase that emphasizes the psychological aspects of addiction and incorporates psychotherapeutic approaches. A review of Meng Gang's research on the smoking behaviors of alcohol dependent individuals revealed that the smoking prevalence among male patients in this demographic ranges from 86% to 97% [4]. Data from 2001-2002 indicated that 3.8% of American adults were alcohol-dependent, 12.8% were dependent on tobacco, and 1.7% were dually dependent on both substances [5]. The prevalence of cigarette smoking is a significant concern within alcohol-dependent populations, as the majority of these individuals smoke, in contrast to the lower smoking rates observed among non-alcohol dependent individuals. Furthermore, alcohol-dependent patients tend to increase their smoking behavior following alcohol consumption [6]. Those who are simultaneously addicted to alcohol and tobacco are more likely to attempt cessation, yet they also exhibit a higher propensity for re-drinking, demonstrate lower adherence to medical recommendations, and experience elevated mortality rates [7]. Research indicates that the smoking prevalence among patients with alcohol dependence ranges from 75% to 90% [8],

Submitted: 26 March 2026 | **Accepted:** 13 July 2026 | **Published:** 13 July 2026

***Corresponding author:** Xu Chen, Department of Psychiatry, Shandong Mental Health Center, Shandong University, Shandong Jinan, 250014, China.

#The first two authors equal to this working

Citation: Han X, Xu Y, Chen X (2026) The Profiles of Time Perception and Inter-Temporal Choice in Alcohol-Dependent Patients with Smoking Behavior and the Effect on Re-Drinking. SM Prev Med Public Health 7(1): 1034.

significantly exceeding the 20% to 30% smoking rate found in the general population [9]. Previous investigations have established a significant positive correlation between tobacco use disorder and the incidence of alcohol use disorder. The portal theory posits that the consumption of one addictive substance may heighten the craving and risk associated with the use of other addictive substances [10]. This pattern of polysubstance abuse can lead to more pronounced cognitive impairments, with smokers potentially facing deficits across various cognitive domains, including inhibition, working memory, and impulsive behavior.

The phenomenon of multi-drug abuse has been shown to result in irreversible impairments in cognitive functions, particularly in the domains of intertemporal decision-making and temporal perception. Research indicates that individuals with alcohol dependence experience deficits in critical cognitive abilities during periods of chronic withdrawal, with some of these deficits intersecting with cognitive functions pertinent to temporal perception, such as attention and executive functioning [11]. A fundamental characteristic of individuals with substance dependence and behavioral addictions is a compromised capacity for intertemporal decision-making. Empirical studies have established a correlation between intertemporal decision-making and time perception among college students and healthy populations [12,13]. Neuropsychological and neuroscientific investigations have consistently demonstrated that excessive alcohol consumption adversely affects cognitive functions and the neural substrates associated with temporal perception. Time perception refers to an individual's subjective experience of time. Patients with substance dependence are often characterized by a tendency to exhibit impatience or impulsivity, which may stem from an intolerance for delays or a subjective overestimation of time, leading to the perception that time elapses more slowly than it actually does [14]. Intertemporal decision-making involves the evaluation of the utility of various options at different temporal intervals (immediate versus future) and the subsequent decision-making process [15]. An understanding of addictive behaviors through the lens of intertemporal decision-making reveals that individuals with addiction are inclined to opt for immediate, smaller rewards—such as the consumption of addictive substances or engagement in addictive behaviors to alleviate stress or withdrawal symptoms—while significantly undervaluing larger, delayed rewards associated with health, familial relationships, social connections, and career advancement. Numerous studies have explored this decision-making framework in populations with substance dependence [16], behavioral addictions [17], attention-deficit/hyperactivity disorder (ADHD) [18], and obesity [19]. However, the behavioral model pertaining to smoking behaviors in individuals with alcohol dependence has yet to be elucidated. This study aims to investigate the differences in time perception and intertemporal decision-making among patients exhibiting high-risk and risky subtypes of alcohol dependence, particularly in the context of co-occurring smoking behaviors. This research not only contributes to the theoretical discourse surrounding time perception, intertemporal decision-making, and alcohol dependence but also seeks to uncover the potential psychological mechanisms underlying resistance to addiction in alcohol-dependent individuals, thereby providing a theoretical foundation and empirical evidence for further elucidating the mechanisms involved in the onset and progression of alcohol dependence.

METHODS

Subjects

A total of sixty-seven patients diagnosed with Alcohol Dependence (AD) were admitted to the Department of Addiction Medicine at Shandong Mental Health Center between July 2021 and March 2022. Based on the Smoking Index (SI), the participants were categorized into three groups: three individuals classified as non-smoking AD (NS group) with an SI of 0, twenty-two individuals identified as light-smoking AD (LS group) with an SI ranging from greater than 0 to 13, and forty-two individuals categorized as heavy-smoking AD (HS group) with an SI exceeding 13. Due to the limited number of patients in the NS group, which consisted of only three individuals, this group was excluded from statistical analysis. The inclusion criteria for the study were as follows: (1) fulfillment of the diagnostic criteria for Alcohol Dependence Syndrome as per ICD-10; (2) age between 18 and 60 years; and (3) an educational level of junior high school or higher, enabling the completion of assessments. The exclusion criteria included: (1) the presence of substance dependence or behavioral addiction other than alcohol or nicotine; (2) any diagnosed mental illness; (3) serious physical health conditions; and (4) severe withdrawal symptoms, defined as a Clinical Institute for Alcohol Withdrawal and Assessment of Alcohol Dependence (CIWA-Ar) score greater than 9. Additionally, a control group comprising forty-two healthy male participants (HC group) who were neither alcohol-dependent nor smokers (defined as individuals who had not smoked 100 cigarettes in their lifetime [20]) was recruited from the local community.

The AD patients underwent enrollment screening within 14 to 21 days of admission, while the HC group participants were selected based on the established inclusion criteria and subsequently completed behavioral task assessments. The study cohort comprised three groups: (1) the LS group (n=22) within the AD group, with participants aged 18–55 years (mean ± SD: 38.91 ± 9.49 years) and education duration ranging from 8 to 16 years (median [IQR]: 11.00[11.00–12.50] years); (2) the HS group (n=42) with participants aged 26–54 years (mean ± SD: 43.64 ± 5.57 years) and education duration of 7–17 years (median [IQR]: 9.50[8.00–12.00] years); and (3) the healthy control group (HC, n=22) with participants aged 18–54 years (mean ± SD: 41.76 ± 9.37 years) and education duration ranging from 7 to 17 years (median [IQR]: 12.00[9.00–14.25] years). Statistical analysis revealed no significant differences in demographic characteristics among the three groups ($P > 0.05$), indicating a satisfactory match.

The study protocol was reviewed and approved by the Ethics Committee of the Shandong Mental Health Center (Approval Number: 2021-R43). All procedures involving human participants were performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Written informed consent was obtained from all individual participants included in the study.

Data Collection

(1) The Clinical Institute Alcohol Withdrawal Scale (CIWA-Ar) is utilized to evaluate the severity of alcohol withdrawal syndrome in subjects. This scale comprises a total of ten items and is standardized for clinical application with a threshold score of 9; scores exceeding this value indicate a state of abstinence. Data entry was conducted using the Double Data Entry method, and a random sample of 10% was selected for consistency checks to ensure the reliability of the data. (2) The smoking index (SI) is calculated as the product of the number of cigarette packs smoked per day and the number of years the individual has been smoking. (3) The behavioral assessment was conducted using Eprime 2.0 software, administered by three trained researchers following standardized instructions in a quiet and undisturbed treatment room, utilizing a 14-inch laptop computer. The assessment comprised three tasks: a. The Time Reproduction Task (TRT) was designed to evaluate the subjects' ability to time their movements, lasting approximately 10 minutes. A white ellipse was displayed at the center of the screen, with random intervals of 1, 2, 3, 4, 5, and 6 seconds. Subjects were instructed to reproduce these time intervals by pressing a key. The Drr values, representing the ratio of reproduced time to actual time, indicate the accuracy of motor timing, with higher Drr values suggesting a subjective overestimation of time. The coefficient of variation (CV) values reflect the variability in motor time perception, with larger CV values indicating greater variability in the subjects' time estimations. b. The Time

Discrimination Task (TDT) was employed to assess the subjects' motor timing abilities, lasting approximately 10 minutes. Two white ellipses were presented successively at the center of the screen, with the first ellipse displayed for 500 milliseconds and the second ellipse presented for a duration randomly selected between 200 and 800 milliseconds. Subjects were required to determine which ellipse was displayed for a longer duration based on their subjective perception of time. Curve fitting was performed using GraphPad Prism 8.0 software, employing the equation $Y=1/\{1+\exp[b\times(x-c)]\}$, where x represents the presentation time of the second ellipse and Y denotes the proportion of responses indicating that the second ellipse was "longer." The b-value reflects the slope of the curve, indicating sensitivity to perceived time differences; smaller b-values suggest reduced sensitivity to these differences. c. The Delayed Discounting Task (DDT) was utilized to assess decision-making over time, taking approximately 15 minutes to complete. On the left side of the screen, smaller immediate rewards were presented, while larger delayed rewards were displayed on the right. Immediate rewards were offered in two amounts, $10 and $100, with delays presented randomly at intervals of 1, 7, 14, 21, 30, 60, 90, 180, and 360 days. Subjects made a series of choices regarding rewards, and the resulting curves were fitted using GraphPad Prism 8.0 software. The equation $LL = SS/(1 + k \times DA)$ represents a hyperbolic function utilized to model delay discounting. In this context, SS denotes the actual value of the reinforcer, while LL signifies the subjective value of the reinforcer following a specified delay time, denoted as DA. The parameter k, which quantifies the delay discount rate, is computed such that a higher value of k corresponds to a more pronounced discounting effect, indicating a stronger immediacy bias, or a propensity to prefer a smaller, immediate reward over a larger, delayed one.

Statistical Methods

All data were subjected to statistical analysis utilizing the SPSS 27. Following the Kolmogorov-Smirnov normality test, variables that exhibited a normal distribution were reported as (x±s), and comparisons among the three groups were conducted using ANOVA. Conversely, variables that did not conform to a normal distribution were presented as [M(QL, QU)], with intergroup comparisons performed using the Mann Whitney U test. All models and graphical representations were generated and analyzed using GraphPad Prism 10.1.2. A p-value of less than 0.05 was considered indicative of a statistically significant difference, while a p-value of less than 0.01 denoted a highly statistically significant difference.

RESULT

Comparison of TRT Outcomes Between Groups

The Drr values at 1s and 2s time intervals in the AD group were larger than those in the HC group (P<0.05); among the 6 time intervals, the CV values in the AD group were larger than those in the HC group (P<0.05); the differences between the Drr values and CV values in the LS group and the HS group were statistically insignificant when compared with those in the HS group (P>0.05), as shown in Supplement Table 1 and 2, and in Figure 1.

The one sample t-test compared the difference between Drr value and 1 in each group, and the results showed that the HC group overestimated 1s[$t_{(41)}$=3.626, P<0.001].underestimated 6s[$t_{(41)}$=-3.557,P<0.001]; 2s[$t_{(41)}$=1.674, P=0.102], 3s[$t_{(41)}$=1.228,P=0.226], 4s[$t_{(41)}$=-0.887, P=0.380], 5s [$t_{(41)}$=-1.751, P=0.088] were correctly estimated. The LS group overestimated 1s[$t_{(21)}$=3.508, P=0.002] and 2s[$t_{(21)}$=3.452, P=0.003].5s[$t_{(21)}$=-4.020,P<0.001],6s[$t_{(21)}$=-3.177,P<0.005] were underestimated. 3s[$t_{(21)}$=0.955,P=0.351], 4s[$t_{(21)}$=-1.079, P=0.294] were correctly estimated. The HS group over estimated 1s[$t_{(41)}$=5.550, P<0.001], 2s[$t_{(41)}$=3.995, P<0.001], and 3s[$t_{(41)}$=2.514,P=0.016]. Underestimated 6s[$t_{(41)}$=-3.715,P<0.001]; 4s[$t_{(41)}$=0.918, P=0.364], 5s[$t_{(41)}$=-0.387, P=0.701] were correctly estimated. The results showed that all three groups of subjects showed overestimation of shorter time distances, underestimation of longer time distances, and correct estimation of intermediate time distances, which was in linewith Vierordt's law. The HC group was able to correctly estimate more intermediate periods (2/3/4/5s) from 2 seconds, while the LS group from 3 seconds (3/4s) and the HS group from 4 seconds (4/5s) were able to correctly estimate only two intermediate periods, and the time shift of Vierordt's law showed with the increase of cigarette consumption in alcohol-dependent patients.

Comparison of TDT Outcomes Between Groups

In the TDT score, the slope b value is the index of the sensitivity of the response perception, and the subjective equality point c value is the index of the accuracy of the response perception time. The b values of the three groups are shown in Figure 2. The Mann-Whitney U test was performed between HC and AD groups and LS and HS groups on b and c values. The results showed that the b value of the AD group was significantly lower than that of the HC group (P<0.01), and the c value of the AD group was lower than that of the HC group, but the difference was not statistically significant, as shown in Supplement Table 3. The b value

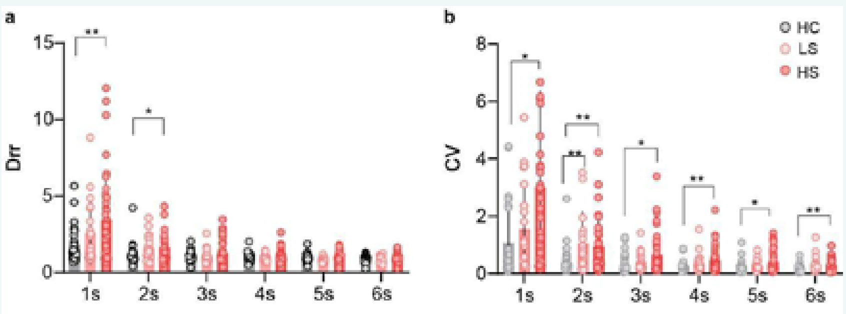

Figure 1.Comparison of TRT outcomes between groups

Figure 1(a): The DRR of the three groups of subjects was compared when the duration was 1~6s. Compared with the HC group, the Drr values of the AD group were significantly higher than those of the HC group at 1s and 2s (P<0.05).

Figure 1(b): The CV of the three groups was compared when the duration was 1~6s. Among the six groups, the CV values of the AD group were significantly higher than those of the HC group (P<0.05)

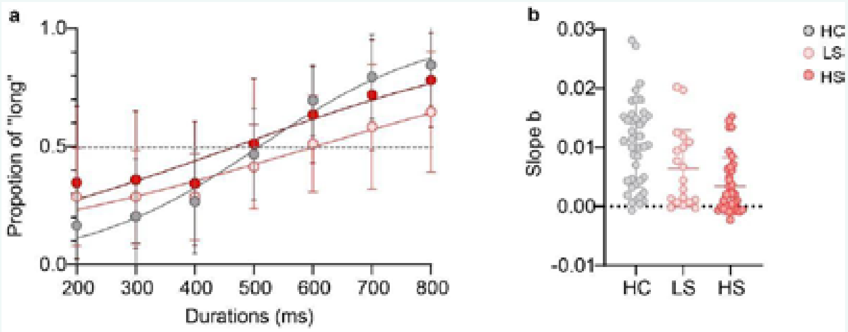

Figure 2.Comparison of TDT outcomes between groups

Figure 2(a): Comparison of the proportion of "long response" to perceptual timing among the three groups. **Figure 2(b):** Comparison of the b-value of the perceptual timing slope of the three groups.

of the HS group was lower than that of the LS group, but the difference was not significant (P>0.05), and the c value of the HS group was lower than that of the LS group, but the difference was not statistically significant, as shown in Table 1.

The one-sample t-test compared the differences between the c-values and 500ms in each group, and the results showed that the c-values of the HC group (t=0.276, P=0.784) and the LS group (t=-0.551, P=0.588) did not differ significantly from 500ms, and the c-value of the LS group was less than 500ms (t=-2.158, P=0.038).

Comparison of DDT Outcomes Between Groups

In the TDT score, the slope b value is a response to perceived time sensitivity, and the subjective equivalence point c value is a response to perceived time accuracy. The b-values of the three groups of subjects are shown in Figure 3. Mann-Whitney U test between two groups, HC and AD group, LS and HS group, was carried out on b-value and c-value. It was found that the b-value of the AD group was significantly lower than that of the HC group (P<0.01), and the c-value of the AD group was smaller than that of the HC group, but the difference was not statistically significant, as shown in Supplement Table 4. b-value of the HS group was lower than that of the LS group, but the difference was not significant (P>0.05), and c-value of the HS group was lower than that of the LS group, but the difference was not statistically significant, as shown in Table 2.

Comparison of Re-Drinking In AD Group with Different Smoking Degrees

Telephone follow-up was conducted at the time point of three months of abstinence in AD group, and the re-drinking situation was shown in Table 3, and the re-drinking rate of the heavy smoking group was significantly higher than that of the light smoking group (P<0.05) by chi-square test.

Binary Logistic Regression Analysis of Influencing Factors of Re-Drinking In Alcohol-Dependent Patients

To further the influence factors of alcohol-dependent patients' post-withdrawal re drinking, alcohol-dependent patients were divided into re-drinking and not re-drinking, groups, and the clinical variables of the two groups: age, education, smoking index, time-perception variables: movement time accuracy (Drr), movement variability (CV), perceived temporality (b), and perceived temporal accuracy (c), and the decision making variables of the intervals: the delayed in the smaller-amount conditions discount rate (k10), and delayed discount rate in the smaller amount condition (k100) for variability, see Supplement Table 5. Then, using whether to re-drinking as the dependent variable Y1, and the factors with P<0.1 in the univariate factors: age (X1), smoking index (X2), and delayed discount rate in the smaller amount condition k10

Table 1: Comparison of TDT results of LS and HS groups M (QL, QU)

	LS(n=22)	HS(n=42)	*U*	*P*
b	0.006(0.001,0.011)	0.003(0.000,0.006)	235.000	0.058
c	541.100(439.700,639.400)	449.300(23.405,503.000)	79.000	0.088

Table 2: Comparison of DDT results of LS and HS groups M (QL, QU)

	LS(n=22)	HS(n=42)	*U*	*P*
k(10)	0.095(0.007,0.360)	0.535(0.138,2.013)	85.500	0.005**
k(100)	0.030(0.004,0.170)	0.121(0.114,0.364)	84.000	0.002**

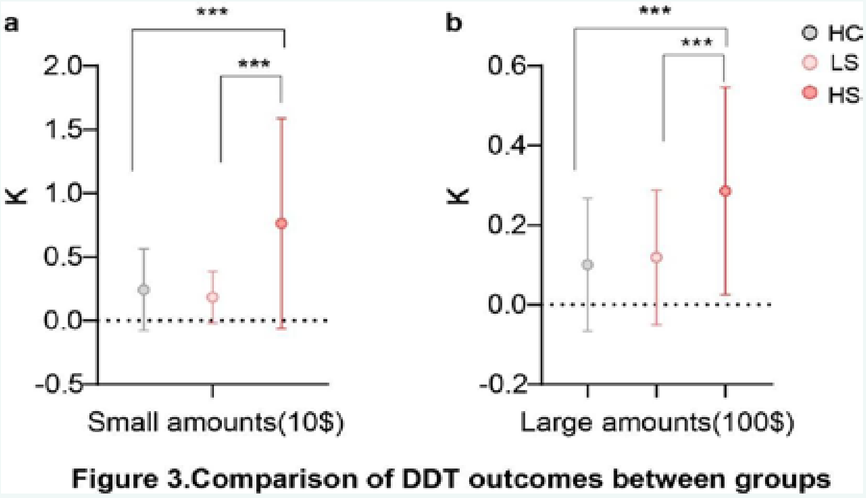

Figure 3: Under different amount conditions, the three groups of subjects k were compared. Under smaller (SS=10) and larger amount conditions (SS=100), the k value of the AD group was significantly greater than that of the HC group (P<0.05).

Table 3: Comparison of re-drinking between LS and HS groups

Group	Not re-drink	Re-drink	Total	X^2	*P*
LS Group	15	7	22	6.112*	0.013
HS Group	15	27	42		
Total	30	34	64		

Table 4: Multivariate binary logistic regression analysis of independent risk factors for re-drinking in AD Group

Factors	*B*	*SE*	*Wald* X^2	*P*	*Exp(B)*	95%CI for Exp(B)	
						Low	High
Age	0.050	0.046	1.181	0.277	1.051	0.961	1.149
SI	0.008	0.022	0.121	0.728	1.008	0.965	1.052
k10	0.328	0.137	5.770	0.016*	1.388	1.062	1.815

(X3) as the independent variables, were included in the multifactor binary Logistic regression, and stepwise backward method was used backward method, setting αin=0.05,αout=0.10.The results showed that the model was statistically significant (P<0.01), and the smaller amount condition delayed discount rate k was the most important factor in alcohol dependence. The results showed that the model was statistically significant (P<0.01) and that the delayed discount rate k in the smaller amount condition was a risk factor for the occurrence of alcohol dependence re drinking (OR=1.388, P=0.016), as shown in Table 4.

DISCUSSION

In the present study, we found that patients in the AD group showed greater overestimation of time periods and poorer discrimination of time periods than the HC group, which may be due to the fact that alcohol intake interferes with brain regions such as prefrontal cortex, cerebellum, and basal ganglia [21], which are considered to be internal timers for an individual's perception of time, and consequently, affects cognitive function performance in time perception. Filip MN et al. [14], concluded that alcohol intake has an adverse effect on time perception function in people with alcohol use disorders, which is consistent with the results of the present study. Meanwhile, patients in the AD group showed a greater preference for immediacy in decision making across time compared to the HC group. Previous studies have identified impaired intertemporal decision-making functioning in the AD group [22]. This may be due to alcohol intake, which leads to abnormal activation of brain regions such as the dorsolateral prefrontal cortex and orbital frontal cortex, which are thought to be closely related to decision-making function in addicts [23].

This study found that AD patients had a high rate of smoking, and the analysis concluded that alcohol and nicotine are both psychoactive substances that can be used legally, and the co-use of tobacco and alcohol not only has a high comorbidity rate, but also affects each other at many physiological and cognitive levels. Other studies [24] have shown a dose-dependent relationship between alcohol and nicotine use. This may be related to the fact that the two substance-dependent individuals share a common susceptibility gene, and the acetylcholine receptor may be the basis for the interaction of the two substances, which can promote the rewarding effect of the two substances [25]. In addition, this study found that AD patients with different smoking levels exhibited different biases in time perception and intertemporal decision-making. There was no significant difference in time perception among AD patients with different smoking degrees in the time replication task and the time discrimination task, which is inconsistent with the original hypothesis of this study, which may be due to the fact that nicotine induces internal clock acceleration [26] (i.e., underestimation of time periods) and alcohol use may cause internal clock deceleration (i.e., overestimation of time periods), and there may be a countervailing effect between the two. Patients with heavily smoking AD are more likely to make intertemporal decisions than those with light smoking behavior, suggesting that they are more likely to have difficulty resisting short-term benefits and are more likely to re-drinking, which may be related to the increased delayed discount rate with nicotine use [27]. In this study, the re-drinking rate of hospitalized patients with alcohol dependence at 3 months after withdrawal was 53.13%, which was basically the same as that of previous studies at home and abroad [28,29], and the re-drinking rate at 3 months after withdrawal in patients with alcohol dependence with heavy smoking behavior was 64.29%, which was significantly higher than the 31.82% rate after withdrawal in patients with alcohol dependence with mild smoking behavior. Telephone interviews showed that the drinking patterns of re-drinking patients were mainly frequent drinking, indicating that the early high re-drinking rate of alcohol dependent patients was a difficult point in treatment, and it is of great significance to explore the risk factors of early re-drinking after withdrawal in alcohol-dependent patients, so as to formulate more effective medical interventions. In previous studies, demographic factors, individual factors, and environmental factors have often been discussed from the perspective of the influencing factors of re-drinking in alcohol dependent patients, and it has been found that factors such as rural household registration, and outpatient follow-up rate are risk factors for re-drinking [29]. This study focused on cognitive features in individual patient factors and found that intertemporal decision-making characteristics are not only important factors that can explain the causes of alcohol dependence, but also have a strong correlation between the delayed discount rate and re-drinking, which has also been described in other addiction disorders, such as gambling dependence [30]. Amlung et al., showed that low treatment adherence in alcohol-dependent patients was associated with area under the curve, another measure that quantifies delayed discounts [31]. As for re-drinking, Fan et al [32]., also observed that high delayed discount rates and other impulsive related factors predicted re-drinking [32]. Therefore, the delayed discount rate can be considered a neurocognitive risk factor that may have a specific impact on the ability of alcohol-dependent patients to complete treatment and remain abstinent.

Thus, the delayed discount rate, an indicator for intertemporal decision-making, may be a useful new therapeutic target or for identifying high-risk populations that require more intensive therapy [33]. In addition to the abstinence treatment of alcohol-dependent patients, cognitive training on the cross-period decision-making mode of patients can also be added to the routine group psychotherapy, so as to help alcohol-dependent patients recognize the immediate preference in decision-making, which is conducive to the maintenance of abstinence. In addition, the follow-up of this study was only set at a time point of three months after withdrawal, and future studies can consider longer follow-up and more follow-up time points, which can be re-evaluated in the outpatient clinic or in the community, so that the recurrence rate can be credible. Fully considering the influence of individual cognitive factors of patients, so as to clarify the recurrence factors of alcohol dependence, is not only conducive to helping patients with alcohol dependence maintain long-term abstinence from alcohol and promote recovery, but also conducive to the publicity and education of addiction prevention for the public. During chronic withdrawal in patients with alcohol dependence, cigarette management should also be emphasized. At present, smoke-free policies are often adopted in the inpatient setting in China, but in the treatment of alcohol dependence, doctors usually do not collect information on cigarette use for diagnostic purposes. The uptake of smoking cessation interventions in treatment programmes was also relatively low. Studies have demonstrated that smoking cessation interventions during chronic withdrawal can contribute to long-term withdrawal, and the underlying mechanisms of efficacy may be related to a range of factors, including prolonged duration of interventions, reduction of smoking as a clue associated with alcohol use, practice of techniques to prevent re-drinking, increased sense of mastery, and a more active lifestyle [34]. It is important to note that there is some controversy about the provision of smoking cessation services in the treatment of alcohol dependence.

There are still some shortcomings in this study: the sample size is small, especially for the comparison of re-drinking in alcohol-dependent patients, and a larger and more representative sample is still needed to determine the generality of the results in the future; Only male alcohol-dependent patients were involved, and the conclusions of the study could not be extrapolated to the female alcohol-dependent patient population; Due to the small number of alcohol-dependent patients without smoking, this group was excluded, and the sample size was increased in the future to better evaluate the effect of the upper limit effect of smoking on the behavioral characteristics of alcohol dependent patients. The smoking index is calculated based on self-report without the inclusion of physiological and biochemical indicators, and future studies can use nicotine intake biomarkers throughout the data collection process, along with self-report measures to more accurately capture tobacco use; This study only revealed cognitive features through cross-sectional studies, so the results of this study should be regarded as preliminary findings and interpreted with caution, and future studies can try to reveal the dynamic changes of features through long-term longitudinal studies. Finally, not only the alcohol-dependent groups but also the smoking rate of dependent groups is generally high. The results of this study suggest that it is necessary to consider the impact of smoking at the same time for research on substance-dependent patients. Time perception and Intertemporal decision-making can be used as observation indicators in future studies, but it should also be considered as an intervention target to promote the further development of prevention and treatment plans in the field of addiction and reduce the recurrence rate. Despite these limitations, this study still objectively evaluates the characteristics of time perception and Intertemporal decision making in patients with chronic withdrawal periods and their re-drinking results, which will better explain the potential interaction between time perception, Intertemporal decision-making and treatment results of alcohol-dependent patients, provide a certain theoretical explanation for the work of reducing the re-drinking rate of alcohol dependent patients, and lay the foundation for the future transformation of such basic research into specific clinical applications.

CONCLUSION

In summary, this study draws groundbreaking conclusions: compared with healthy controls, alcohol-dependent patients showed an overestimation of the sports time period and greater variability, a less sensitive perception of the perceived time, and an immediacy bias in intertemporal decision-making. Compared with patients with alcohol dependence with mild smoking behavior, patients with alcohol dependence with severe smoking behavior have a more prominent bias in intertemporal decision-making. Intertemporal bias (higher delayed discount rates) may be a risk factor for re-drinking.

DECLARATIONS

Ethics Approval and Consent to Participate

The study was approved by the Ethics Committee of Shandong mental health center,and every patient and their family fully understand and submitted their written consent to participate into this study.

CONSENT FOR PUBLICATION

Consent for publication was obtained from all participants involved in the study.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

COMPETING INTERESTS

The authors declare no competing interests.

FUNDING

This study was funded by the Shandong Provincial Medical and Health Science &Technology Development Plan(2016WS0398).

AUTHORS' CONTRIBUTIONS

Xiaoyuan Han, Yangyang Xu and Xu Chen conceived and designed the study. Yangyang Xu and Xiaoyuan Han collected the data and performed the data analysis. All authors contributed to manuscript writing and approved the final manuscript.

ACKNOWLEDGEMENTS

We thank Shandong Mental Health Center for their support during this research.

REFERENCES

1. Organization W H. Global Status Report on Alcohol and Health. 2018
2. GBD 2016 Risk Factors Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990-2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet. 2017; 390: 1345-1422.
3. Dong P, Yi J L, Wu F, Ni Z J, Zhao K Q, Sun G Q, et al. Investigation on the related factors of increased drinking craving and alcohol consumption among drinkers during the COVID-19 pandemic. Chinese Journal of Drug Dependence. 2021; 30: 38-44.
4. Meng G, Liu T Q, Hao W, Wang X Y. Research progress on the comorbidity of alcohol dependence and tobacco dependence. Chinese Journal of Drug Dependence. 2008; 325-329.
5. Hughes JR, Novy P, Hatsukami DK, Jensen J, Callas PW. Efficacy of nicotine patch in smokers with a history of alcoholism. Alcohol Clin Exp Res. 2003; 27: 946-54.
6. Bien T H, Burge R. Smoking and drinking: a review of the literature. Int J Addict. 1990; 25: 1429-1454.
7. Li P, Sun H Q, Wang F, Lu L. Research progress on the comorbidity mechanism of nicotine dependence and alcohol dependence. Chinese Journal of Drug Dependence. 2010; 19: 321-324.
8. Hughes JR, Kalman D. Do smokers with alcohol problems have more difficulty quitting? Drug Alcohol Depend. 2006; 82: 91-102.
9. Li X H. 2018 China Adult Tobacco Survey Report. People's Medical Publishing House. 2018
10. Yang L, Cao H, Geng Y F, Xu J, Zhang Y, Su B B. Adolescent substance addiction from the perspective of gateway theory. Advances in Psychological Science. 2016; 24: 1237-1245.
11. Zahr NM, Pfefferbaum A. Alcohol's Effects on the Brain: Neuroimaging Results in Humans and Animal Models. Alcohol Res. 2017; 38: 183-206.
12. Han F. An analysis of time perception and its influence on intertemporal choice among postgraduate entrance exam candidates (Master's thesis). 2018.
13. Suo T, Zhang F, Zhao G X, Li H. The effect of differences in time perception on intertemporal choice tendency. Acta Psychologica Sinica. 2014; 46: 165-173.
14. Nuyens FM, Billieux J, Maurage P. Time perception and alcohol use: A systematic review. Neurosci Biobehav Rev. 2021; 127: 377-403.
15. Amasino DR, Sullivan NJ, Kranton RE, Huettel SA. Amount and time exert independent influences on intertemporal choice. Nat Hum Behav. 2019; 3: 383-392.
16. Moses TEH, Burmeister M, Greenwald MK. Heroin delay discounting and impulsivity: Modulation by DRD1 genetic variation. Addict Biol. 2020; 25: e12777.
17. Odum AL, Becker RJ, Haynes JM, Galizio A, Frye CCJ, Downey H, et al. Delay discounting of different outcomes: Review and theory. J Exp Anal Behav. 2020; 113: 657-679.
18. Mies GW, Ma I, de Water E, Buitelaar JK, Scheres A. Waiting and working for rewards: Attention-Deficit/Hyperactivity Disorder is associated with steeper delay discounting linked to amygdala activation, but not with steeper effort discounting. Cortex. 2018; 106: 164-173.
19. Rodriguez LR, Rasmussen EB, Kyne-Rucker D, Wong M, Martin KS. Delay discounting and obesity in food insecure and food secure women. Health Psychol. 2021; 40: 242-251.
20. Yu F, Xiao R, Li X, Hu Z, Cai L, He F. Combined effects of lung disease history, environmental exposures, and family history of lung cancer to susceptibility of lung cancer in Chinese non-smokers. Respir Res. 2021; 22: 210.
21. Kunimatsu J, Suzuki TW, Ohmae S, Tanaka M. Different contributions of preparatory activity in the basal ganglia and cerebellum for self-timing. Elife. 2018; 7: e35676.
22. Kvam PD, Romeu RJ, Turner BM, Vassileva J, Busemeyer JR. Testing the factor structure underlying behavior using joint cognitive models: Impulsivity in delay discounting and Cambridge gambling tasks. Psychol Methods. 2021; 26: 18-37.

23. Halcomb M, Dzemidzic M, Shen YI, Lin Z, Butcher TJ, Yoder KK,et al. Delay discounting and alcohol consumption correlate with dorsal anterior insula activation during choice in nontreatment-seeking heavy drinkers. Alcohol Clin Exp Res. 2022; 46: 1397-1407.

24. Cui Z Y. A study on the prevalence of tobacco dependence, alcohol dependence and the correlation between smoking and drinking in China (Doctoral dissertation). 2022.

25. Ma Y Y, Zheng W, Xue B, Zhu J Y, Liang J, Zhang J J. Psychological processing of addictive memory retrieval and its neural circuit basis. Chinese Journal of Drug Abuse Prevention and Treatment. 2023; 29: 1-6.

26. Daniels CW, Watterson E, Garcia R, Mazur GJ, Brackney RJ, Sanabria F. Revisiting the effect of nicotine on interval timing. Behav Brain Res. 2015; 283: 238-250.

27. MacKillop J, Kahler CW. Delayed reward discounting predicts treatment response for heavy drinkers receiving smoking cessation treatment. Drug Alcohol Depend. 2009; 104: 197-203.

28. Tao YJ, Hu L, He Y, Cao BR, Chen J, Ye YH, et al. A real-world study on clinical predictors of relapse after hospitalized detoxification in a Chinese cohort with alcohol dependence. PeerJ. 2019; 7: e7547.

29. Wang J, Xu P Z, Wang Q, Yang M. Follow-up survey on early relapse of patients with alcohol dependence after discharge from treatment. Chinese Journal of Drug Dependence. 2022; 31: 335-339.

30. Mena-Moreno T, Testa G, Mestre-Bach G, Miranda-Olivos R, Granero R, Fernández-Aranda F, et al. Delay Discounting in Gambling Disorder: Implications in Treatment Outcome. J Clin Med. 2022; 11: 1611.

31. Amlung M, Yurasek A, McCarty KN, MacKillop J, Murphy JG. Area under the curve as a novel metric of behavioral economic demand for alcohol. Exp Clin Psychopharmacol. 2015; 23: 168-75.

32. Fan Y L, Wang J K, Li Q, Niu Y J, Yang Y, Sun H Q. Effects of different dimensions of impulsivity on relapse in patients with alcohol dependence. Journal of Psychiatry. 2019; 32: 92-95.

33. Cheong J, Rung JM, Tucker JA. Bidirectional prospective associations between behavioral economic indicators and drinking patterns during alcohol use disorder natural recovery attempts. Psychol Addict Behav. 2023; 37: 104-113.

34. Goodwin RD, Wu M, Davidson L. An empirical perspective on cigarette use in substance use recovery. Psychol Med. 2021; 51: 2299-2306.