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Inhibitory capacity assessment in alcohol dependent patients: translation from a modified stop signal task

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Introduction. Inhibitory control is clearly impaired in alcohol dependent individuals, being associated to the addiction process establishment and abstinence maintenance difficulties. Inhibitory control assessment tasks involving responses to neutral stimuli are available, although a Spanish version task including contextual cues influence on inhibition capacity has not been performed yet. Alcohol related stimuli can modify behavioural inhibition performance. Thus, the purpose of this study was the Spanish translation of a modified stop signal task that assessed inhibitory control, as well as the degree of interference produced by the presence of alcohol related words.

Methodology. A modified stop signal reaction task, based on a fast lexical decision paradigm was employed. Stimuli used were translated from Zack et al.[1], according to frequency of use in Spanish, including neutral words, pseudowords and alcohol-related words. Task was applied to 85 alcohol dependent patients, with a minimum of 28 days of abstinence and to 27 healthy participants constituting the control group.

Results. Patients showed a poorer performance, with a lower stop signal mean delay comparing to control group, in presence of neutral and alcohol-related words.

Conclusions. Alcohol dependent individuals exhibit a lower behavioural inhibition performance, added to a significant influence of contextual cues on the stop signal task, resulting in impulsive behaviour, only in the patients group.

Keywords: Alcoholism, Stop signal task, Inhibition, Executive function

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Evaluación de la capacidad de inhibición en dependientes de alcohol: traducción de la tarea de la señal de stop modificada

Introducción. La capacidad inhibitoria se encuentra claramente alterada en personas dependientes del alcohol, asociándose a conductas que contribuyen al establecimiento de la dependencia y dificultando el mantenimiento de la abstinencia. Se dispone de tareas que evalúan la capacidad inhibitoria cuando un estímulo neutro desencadena la respuesta, como la tarea de la señal de stop, aunque no existe una prueba en castellano que incorpore la influencia de claves contextuales en la capacidad inhibitoria. La presencia de estímulos relacionados con el alcohol modifica la capacidad de inhibición conductual. Así, el objetivo de este trabajo fue traducir al castellano una tarea de señal de Stop Modificada que evaluara, además del control inhibitorio, el grado de interferencia que produciría la presencia de palabras relacionadas con el alcohol.

Metodología. Se empleó la tarea de la señal de stop modificada, basada en un paradigma de decisión léxica rápida. Los estímulos empleados fueron traducidos de la tarea de Zack et al.[1], en función de la frecuencia de uso en castellano, incluyendo palabras neutras, pseudopalabras y relacionadas con el alcohol. Se aplicó a 85 pacientes dependientes del alcohol, con 28 días de abstinencia mínimos y a un grupo control de 27 sujetos.

Resultados. Los pacientes presentaron un peor rendimiento, teniendo menores demoras medias ante la señal de stop que el grupo control, ante palabras neutras y relacionadas con el alcohol.

Conclusiones. Las personas dependientes del alcohol tienen menor capacidad de inhibición conductual, con influencia contextual significativa solo para los pacientes, que interfiere claramente dando lugar a conductas impulsivas.

Palabras clave: Alcoholismo, Señal de stop, Inhibición, Función ejecutiva

INTRODUCTION

Cognitive functions altered in the addiction process such as attention, inhibition and cognitive flexibility represent key elements implicated in cue related self-monitoring behavior and action planning updates[2]. These processes have been observed in studies with alcoholic patients, evidencing prepotent response inhibition failing and sensitivity to alcohol related cues interference[1,3-5]. Furthermore, state or trait impulsivity has shown to be a key element in successful inhibition of inappropriate behavior, confirming its relevance in substance seeking and consuming behavior, as well as abstinence maintenance failing[6-9]. These alterations may come as a substance use consequence or they can result from an individual trait, predisposing towards addiction[10]. Impulsivity and heightened alcohol stimuli salience are considered as key elements in abstinence, craving, binge and intoxication cycle[9].

A vast majority of behavioral paradigms assessing inhibition impose a need to adjust response strategies when several task are being presented, asking individuals to quickly respond in front of a stimulus and giving them the instruction to withhold their response when another stimulus is being presented[11]. Representative examples are given by the Go/No Go paradigm and stop signal task (SST). In the stop signal task, Go signal always precedes the stop signal, meaning SST assesses inhibition once the action has been initiated (action cancellation)[12,13]. Additionally, SST offers the possibility to measure inhibitory process latency and its efficacy[14]. The key handling variable in this task is the stop signal delay (SSD)[15], representing the elapsed time between target start and stop signal presence. Inhibitory performance is quantified through stop signal reaction time (SSRT). This task assesses inhibitory deficits involved in addiction[1,16-18], results from alcohol dependent patients showing that a high and/or continuous consumption affects response inhibition, measured by Go/No Go paradigms and SST. Studies have also observed that an altered inhibition response could predict alcohol related problems in vulnerable adolescents[19] and, next to trait impulsivity it could predict alcohol consumption[7]. Nevertheless, in the study of impulsivity and attentional bias difficulties present in alcohol dependent patients, applying a stop signal task can result useful although insufficient to assess the interference occurring due to salience of contextual cues, specifically related to the substance. Thus, alcohol-related cues have been included in several studies under stop signal or Go/No Go paradigms, in order to observe the level of interference (under different modalities: e.g. semantic categories) and inhibitory response performance[1,3].

Regarding studies which include stimuli with emotional content (words), different Go reaction times to these stimuli have been observed, when comparing to stimuli with neutral content[20-24]. If the high incentive value acquired by alcohol related stimuli is considered, next to emotional valence changes of reinforcement during the addiction process[9,25] a similar effect as to affective stimuli presence would be expected for alcohol related words, boosting perceptive and cognitive processes underlying a lexical task. Including this aspect into impulsivity assessment under the stop signal paradigm would provide additional information associated to inhibitory control, given alcohol dependent subjects would show a poorer performance in this task, possibly due to the interference produced by alcohol related stimuli.

Thus, the main goal of this study was the Spanish translation of a modified stop signal task (MSST), assessing the level of interference produced by alcohol related stimuli presence, besides inhibitory control difficulties, through Stop (SSRT) and Go reaction times measures, as well as the stop signal delay (SSD). The words meaning (related or not to alcohol) would have an impact on the reaction times[23,26]. To this end, Zack et al.[1] modified stop signal task assessing response inhibition and interference effect including a lexical decision task between words with neutral, alcohol-related content and pseudowords was used.

METHODOLOGY

An observational study was completed, including 102 alcohol dependent patients attending the alcohol detoxification and recovery treatment program from the Psiquiatry Unit of 12 de Octubre Hospital, participants with psychiatric comorbidities and/or neurological history (e.g. epilepsy, brain injury or alcohol related dementia) being excluded. This number was determined by the need of the behavioral paradigm to predict relapses (estimated as 60-70% in the first 12 weeks) and the number of individuals abandoning the study (approx. 20-25% in the first 12 weeks). Usually, the abandonment causes are related to patients' availability

for the study and treatment leaves-up, possibly due to employment reinstatement or treatment following at their correspondent mental health centre. Therefore, 85 patients (63 males) have completed the study, likely to be used as data for statistical analysis. Age of participants oscillated between 27 and 66 years old. The mean age for initial alcohol consumption was 18 years, with 34 years mean for dependence problems and an average of 270.6 g for alcohol quantity consumption. Also, 44.4% of participants inside the patients group had a minor consumption of additional substances. Inclusion criteria inside the patients group were: 14 average drinks (women) or 21 (men) per week, in a consecutive 30 days period, 90 days before initiating abstinence. Patients confirmed 2 or more days of high consumption (defined as 4 drinks for women and 5 for men) during the 90 days previous to abstinence. A maximum period of abstinence of 28 days and the absence of significative symptoms of withdrawal (CIWA>8) were required before the assessment (medical detoxification and higher CIWA scores 72 hours prior to abstinence beginning were allowed).

Concerning the control group, 27 healthy individuals similar in age, gender and sociodemographic variables were assessed. Individuals with history of psychiatric and or neurological problems were excluded. All participants signed an informed consent. In addition, the presented data is part of a broader project, approved by the ethical committee of the Biomedical Research Institute of 12 de Octubre Hospital.

Materials

Assessment took place at the beginning of detoxification treatment, after two weeks of abstinence. The following tests were used: SCID (Structurated Clinical Interview for DSM-IV I and II axis), CIWA-R (Clinical Institute Withdrawal Assesment for Alcohol, Sullivan et al. 1989)[27], Alcohol Dependence Intensity Scale (Escala de Intensidad de Dependencia Alcohólica, EIDA)[28], and Hamilton Depression[29] and Anxiety Scales[30].

Procedure

Task was administered through a computer (60 cm visual distance) and consisted of a series of quick lexical decision trials (words or pseudo words) established as primary stimuli, each with a visual target positioned at the center of the screen. Each trial, the subject had to press one of two buttons indicated in order to respond as quickly and accurate as possible: pressing "z" with the left finger for pseudowords or "-" with the right finger for words. Instructions were given orally and on the screen. The used stimuli were translated according to frequency of use in Spanish language, from those used in Zack et al.[1] 192 neutral words were included (160 in 8 blocks and 32 for training). Therefore, all sets of stimuli (neutral, alcohol-related words and pseudowords) were paired in number of letters, syllables, accent pattern and frequency of use, in order to reduce the possible differences between them. Firstly, two training blocks of trials were used: one with the lexical decision task and a second one including the stop signal task, with 16 neutral words and 16 pseudowords each. Secondly, 8 blocks of trials were presented, selecting 20 neutral words, 20 alcohol content words and 40 pseudowords for each block. An example of the words and pseudowords used is shown in Table 1.

The Stop signal occurred randomly in 25% of trials, for each type of Go stimuli, allowing the extraction of separated SSRT for each category. The procedure was similar to the one used in the original (x/o) Logan et al.[31] Events presented in each trial were: fixation stimuli (+ + + +; 500 ms, centre of the screen)/1000 ms blank/string (1000 ms Go; 18 pts)/1000 ms blank. In Stop trials, an auditory stimuli (1000 Hz, 100 ms) was presented with a variable delay (SSD) adjusted to 350 ms (>250 ms used in the original SST, reflecting a greater time needed for lexical decision comparing to an ortorgraphical one). The algorithm varied the SSD in Stop trials. If the participant retained his response, SSD became 50 ms longer, making response inhibition more difficult in the next trial; if the subject failed to retain his response, SSD was 50 ms shorter, making the next trial easier. This way, the algorithm adjusted progressively SSD in order to identify the temporal interval associated to 50% of successful inhibition. SSD used for calculating SSRT was the averaged SSD in all Stop trials, for each type of stimuli[27]. Resulting variables from MMST were: percentages and reaction times (miliseconds) for correct answers and errors in lexical classification (Go trials) and successful response inhibition and commission (Stop trials).

Data analysis

Firstly, data normality distribution was tested through Kolmogorov Smirnov and/or Shapiro-Wilk. In order to compare data obtained from both groups in stop signal task variables, non-parametric Mann Whitney U test was used. Subsequently, non parametric testing for repeated measures Friedman and Wilcoxon signed-rank tests were used, in comparing MMST variables distributions, using Bonferroni correction for multiple comparisons. Having 3 posthoc comparisons, the level of significance considered was set as p=0.017.

Table 1 Word used as stimuli for the modified stop signal task. Trial block 1

			Block 1								
Alcohol	L (x=6.4)	S (x=2.55)	Word	L (x=6.65)	S (x=3)	Pseudo[1]	L	S	Pseudo[2]	L (x=6.5)	S (x=2.8)
pimplar	7	2	auditorio	9	5	dióngalo	8	4	runtario	8	4
bar	3	1	muro	4	2	pretilo	7	3	meslo	5	2
botella	7	3	marco	5	2	cun	3	1	mosne	5	2
vino	4	2	sótano	6	3	pránelo	7	3	trólano	7	3
bodega	6	3	tejado	6	3	tarna	5	2	teuleno	7	3
barril	6	2	concreto	8	3	potule	6	3	trontero	8	3
cointreau	10	2	cartero	7	3	teune	5	2	ruster	6	2
chato	5	2	zaguán	6	2	crunera	7	3	expurte	7	3
tinto	5	2	aviador	7	4	laro	4	2	cinodor	7	3
jarra	5	2	encerar	7	3	balzi	5	2	ontirar	7	3
ginebra	7	3	ascensor	8	3	cila	4	2	forenor	7	3
chupito	7	3	cálido	6	3	depanco	8	3	cádino	6	3
gintonic	8	3	pantalón	8	3	cánide	6	3	panjelón	8	3
resaca	6	3	cubierto	8	3	tránera	7	3	fullerto	8	3
bebida	6	3	cemento	7	3	bonena	6	3	vastendo	8	3
taberna	7	3	escenario	9	5	letenida	8	4	pluzonario	10	5
tostada	7	3	patio	5	3	eronor	6	3	explunio	8	4
bebe	4	2	casco	5	2	caniza	6	3	zisdo	5	2
bourbon	7	2	tímpano	7	3	carar	5	2	plasquino	9	3
abstinencia	11	5	punta	5	2	tundil	6	2	binca	5	2

L: number of words letters; S: number of words syllables; x: arithmetic mean.

In order to test the task's capacity to correctly detect cases, a ROC curve analysis was carried out, obtaining sensitivity and specificity values for reaction times (RT) for Go, Stop and SSD processes in each stimulus category (neutral words, alcohol-related words and pseudowords).

RESULTS

Psychopatological data in patients' group

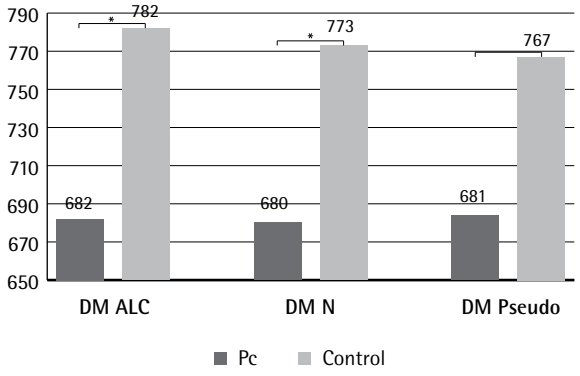
EIDA results show a mean score of 29.57 (SD. 16.66). Patients did not show clinical symptoms of anxiety or

depression measured by Hamilton's scales of anxiety (mean 10.54 y SD. 9.1) and depression (mean 8.94 y SD. 7.73).

Modified Stop signal task

Normality tests through Kolmogorov-Smirnov and/or Shapiro-Wilk, revealed an abnormal distribution, thus further non parametrical testing was needed. Table 2 shows Go, Stop reaction times, lexical decision errors and commissions and SSD from the modified stop signal task, next to Mann Whitney U comparisons between patients and healthy controls.

Significant differences between groups were observed, for lexical decision correct answers as a percentage (mean=44.87 y 50.18; SD=12.5 and 12.8; mean range=51.72 and 67.13, respectively) and commission errors when neutral words were presented (patients mean=55.01 and controls mean=49.81; SD=12.5 and 12.8; mean range=59.19 and 44.17 respectively), z values for z Mann Whitney U were -2.188 (p=0.029) and z= -2.131 (p=0.033), respectively.



Stop signal delays for patients (Pc) and control group, in al three conditions: DM_Stop_Alc, DM_Stop_N y DM_Stop_Ps, representint stop signal delay while alcohol-related words, neutral words and pseudowords are presented. * indicates the level of significante (p value < 0.005) reached when comparing means (through *Kruskal-Wallis* test) between both groups of study for each condition

Figure 1 — *Stop signal delay when alcohol-related, neutral words and pseudowords are presented*

Regarding RT, significant differences for general SSD (p=0.038), alcohol related words SSD (p=0.049) and neutral words SSD (p=0.049) were found (Table 2). This was not found for pseudowords SSD (Figure 1). These results indicate a poorer capacity for response retention when alcohol-related words and neutral words are presented in patient's group. Additionally, a near-significant difference was found for pseudowords in SSD (p=0.057). However, SSRT differences for each type of stimuli were not found in group comparisons.

Friedman intra-group comparisons revealed significant differences between Go RT (Chi Square χ^2=17.63, p<0.1), SSRT (χ^2=13.03, p<0.1) and Stop commissions RT (χ^2=52.69, p<0.01) for each stimuli category in patients' group. Control group comparisons show differences for commissions TR (χ^2=20.51, p<0.01). Wilcoxon post-hoc analysis with Bonferroni corrections (p=0.017) in patients' group revealed significant superior values for pseudowords Go RT compared to neutral (Wilcoxon z=-4.708, p<0.001) and alcohol (Wilcoxon z=-2.701, p=0.007) Go RT. Furthermore, Go RT values for alcohol-related words were superior to Go RT for neutral words (Wilcoxon z=-2.611, p=0.009), hence RTs had the following relationship Ps>Alc>N.

Concerning commission errors, specifically RTs during this type of error, alcohol-dependent patients had significant differences between pseudowords commission RTs and the other categories, alcohol (Wilcoxon z=-5.621, p<0.001) and neutral (Wilcoxon z=-5.621, p<0.001), consequently Alc_Incor_stop> N_Incor_stop> Ps_Incor-stop. On the other hand, control group analysis revealed significant differences between commissions errors RT for the same type of stimuli as for patients group: pseudowords and alcohol (z Wilcoxon=-2.787, p=0.005), and pseudowords and neutral words (Wilcoxon z=-3,628, p<0.001), although with a light shift in direction of differences, that is RTs for N_Incr_Stop>Alc_Incor__Stop> Ps_Incor_Stop.

Ultimately, intragroup comparisons for SSRT detected significant differences between the three categories only in alcohol-dependent individuals, patients showing greater SSRTs when pseudowords (Wilcoxon z=3.292, p<0.001) are presented compared to neutral words and alcohol-related words (Wilcoxon z=-2.556, p=0.011) (SSRT-Ps>SSRT-Alc>SSRT-N). Figure 2 displays SSRT graphs/charts for each type of stimuli, within each group.

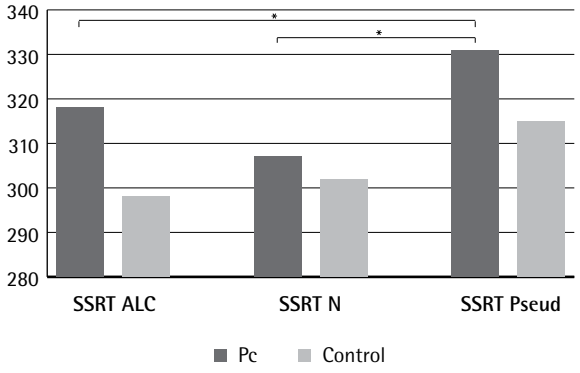
Sensitivity and specificity tests were carried out, through ROC curve analysis. Table 3 shows mean values obtained for patients and controls in each measure, with their correspondent sensitivity and specificity level, next to an ideal score for a satisfactory specificity value. Results exposed adequate specificity values for SSRT for each type

Table 2 Means, mean ranges and Z (Mann Whitney U) for main modified stop signal task measures

Stop variables	*Group*	Mean	SD	Mean Range	Z (Mann-Whitney U)	p
ALC_Cor_TR	*1*	1008.68	146.37	53.02	-1.427	0.153
	2	1081.37	199.22	63.11		
ALC_Incor_TR	*1*	682.55	413.32	52.78	-1.568	0.117
	2	799.49	483.94	63.85		
ALC_Incor_Stop	*1*	40.63	30.76	53.79	-0.986	0.324
	2	44.43	35.17	60.76		
N_Cor_TR	*1*	995.58	130.72	52.66	-1.636	0.102
	2	1076.65	195.68	64.22		
N_Incor_TR	*1*	766.27	406.79	52.56	-1.695	0.09
	2	951.81	296.43	64.54		
N_Incor_Stop_TR	*1*	40.52	22.75	53.13	-1.365	0.172
	2	48.52	30.65	62.78		
Ps_Cor_TR	*1*	1024.17	133.44	53.51	-1.149	0.25
	2	1083.35	180.66	61.63		
Ps_Incor_TR	*1*	785.07	412.57	53.02	-1.427	0.153
	2	850.69	517.29	63.11		
Ps_Incor_Stop_TR	*1*	18.99	15.58	53.30	-1.268	0.205
	2	25.83	14.18	62.26		
DM_Stop_Alc	*1*	682.84	211.75	51.89	**-2.084**	**0.037***
	2	782.79	226.29	66.61		
DM_Stop_N	*1*	680.74	210	52.09	**-1.966**	**0.049***
	2	773.55	235.04	65.98		
DM_Stop_Ps	*1*	684.33	203.65	52.20	-1.9	0.057
	2	767.40	223.68	65.63		
DM_Stop	*1*	789.16	296.11	51.92	**-2.079**	**0.038***
	2	946.30	351.35	66.50		
SSRT_Alc	*1*	318.17	173.59	57.88	-0.799	0.424
	2	298.58	169.84	52.15		
SSRT_N	*1*	307.42	169.31	56.44	-0.037	0.97
	2	303.1	156.44	56.70		
SSRT_Ps	*1*	331.85	184.68	57.72	-0.704	0.481
	2	315.95	137.6	52.67		

Table 2 Continuation

Means and standard deviation (SD), mean renges, Z for Mann Whitney U and p values, for patients (1) and controls (2) in the modified stop signal task variables:ALC_Cor_RT, N_Cor_RT,Ps_Cor_RT representing alcohol, neural and pseudowords Go reaction times (ms); ALC_Incor_RT, N_Incor_RT, Ps_Incor_RT representing lexical decisions errors reaction times; DM_Stop_Alc, DM_Stop_N y DM_Stop standing for stop signal delay when alcohol related, neutral words and pseudowords were presented, SSRT_ALC, SSRT_N y SSRT_Ps for alcohol, neutral words and pseudowords stop signal reaction times; these measures were derived from stop signal delays substraction from Go reaction times in all three conditions, following Logan and Cowan (1984).



Stop signal reacction times in all three conditions, for patients (Pc) y control group: SSRT_ALC, SSRT_N y SSRT_Ps, representing stop signal reaction times while alcohol-related words, neutral words and pseudowords are presented. * indicates the signficance level reached (p<0.017) when comparing between conditions (through Wikoxon test), evidence in patientes'group only.

Figure 2 *Stop signal reaction times when alcohol related, neutral words and pseudowords are presented*

of stimuli, although low sensitivity values were observed. SSRT_ALC variable exhibited the highest specificity value (0.77 and 0.6 for mean values of this variable in patient and control group, respectively).

DISCUSSION

The main goal of this study was assessing the inhibitory capacity in alcohol dependent patients when alcohol-related stimuli Go were presented, using a modified stop signal task[1] Spanish translation. Patients showed a poorer performance than controls, having significantly lower stop signal delays in presence of neutral and alcohol-related words. In this manner, we could conclude that patients exhibited a reduced behavioral inhibitory capacity, showing a greater impulsivity in motor execution and less success in response inhibition. These findings are comparable to data obtained by other studies, assessing alcohol influence on stop signal task execution[7,19,32] and they are suitable to dependence and relapse processes theories that include impulsivity as a key aspect[6,8,9].

Nevertheless, not all variables associated to inhibitory capacity have confirmed our hypothesis, given no significant differences were found between patients and controls for stop signal reaction times (SSRT) in any type of condition, somehow contradictory to other studies' outcomes[7,32,33]. A recent meta-analysis[34] found higher SSRTs for alcohol dependent patients, however, moderate size-effects and heterogeneous Stop measures values were observed. Novel studies on (motor) impulsivity measured by behavioral Stop and Go/No Go show different outcomes in relation to alcohol consumption effect (short and long term effect)[35-42]. On one hand, self-informed measures of impulsivity, such as BIS-II[37,40,41] and Go/No Go reaction times have been associated to recent, problematic use[42] and alcohol-dependence, as well as addiction severity[39]. On the other hand, some of the most recent studies including stop signal tasks found similar results to ours regarding stop signal reaction times (SSRT) in binge or dependent alcohol consumption alcohol[35,36,39,42,43]. The variety of these results can be partially attributable to differences in the paradigms used, sample dissimilarities in gender, age, sociodemographic and alcohol consumption related variables. However, as previously indicated, SSD were significantly lower in patients' group for alcohol and neutral words conditions, which, alongside a greater number of commission errors, could reflect a more prominent impulsivity for patients' group compared to control group.

Table 3 Sensitivity and specificity test for Go, Stop reaction times and stop signal delays

Stop variables	*Group*	Curve coordinates ROC	Sensitivity	Specificity	Area below the curve	p
ALC_Cor_TR	*1*	1008.68	0.54	0.407	0.408	0.153
	2	1081	0.349	0.444		
N_Cor_TR	*1*	995	0.518	0.4	0.395	0.102
	2	1076	0.24	0.519		
Ps_Cor_TR	*1*	1024	0.556	0.407	0.426	0.250
	2	1083	0.33	0.556		
DM_Stop_Alc	*1*	675	0.699	0.185	0.366	0.037*
	2	800	0.494	0.333		
DM_Stop_N	*1*	680.7	0.578	0.296	0.374	0.049*
	2	782	0.373	0.444		
DM_Stop_Ps	*1*	684.3	0.554	0.333	0.378	0.057
	2	773	0.337	0.407		
DM_Stop	*1*	789.16	0.49	0.33	0.367	0.039*
	2	946	0.3	0.4		
SSRT_Alc	*1*	318	0.318	**0.778**	0.551	0.424
	2	298	0.388	0.63		
SSRT_N	*1*	307	0.29	**0.667**	0.498	0.970
	2	303	0.318	0.667		
SSRT_Ps	*1*	311	0.48	**0.63**	0.545	0.481
	2	315	0.471	0.667		

Coordinates values for ROC curve, Sensitivity and Specificity values for patients (1) and controls (2), for Go variables (Alc_Cor_RT, N_Cor_RT, Ps_Cor_RT), Stop (SSRT_Alc, SSRT_N, SSRT_Ps) and stop signal delays (DM_Stop, DM_Stop_Alc; DM_Stop_N; DM_Stop_Ps) for each type of stimuli. Values for area below the curve and asymptotic significance levels are added. In bold: medium-high specificity values.

Regarding alcohol cues' influence, greater SSRTs and lower SSDs were found in alcohol related words presence compared to neutral words in patients' group, this difference not being observed for healthy controls. Additionally, alcohol dependent patients showed a significantly lower inhibition capacity towards pseudowords compared to any other condition. Meanwhile, inhibitory capacity in presence of neutral words was higher than the correspondent for alcohol related words, although this difference did not result statistically significant. Additionally, ROC curve analysis exhibited a higher specificity value for alcohol related words SSRT compared to the other conditions, indicating a possible influence in inhibition process's efficiency. Studies including alcohol related contextual cues in stop signal tasks show a

greater (motor) impulsivity towards alcohol images in social or moderate alcohol drinkers[44,45]. Likewise, higher Go RTs for alcohol related words were found compared to neutral words, only for alcohol dependent patients. This result may appear opposite to our initial hypothesis, regarding a possible acceleration of Go processes in lexical decision when stimuli with emotional content are presented[22,46], giving rise to faster Go RTs, possibly due to the affective and evocative nature of alcohol-related stimuli[9,25]. This study is not the only one observing these outcomes; Nöel et al. found the similar effects in a modified Go/No Go task, discarding a probable enhanced effect in information speed processing as a result of cognitive decline associated to chronic alcohol effects, an idea in line with our results, suggesting patients show an early attentional bias towards alcohol related cues[1,3]. Similar outcomes were found in lexical decision[47] or emotional Stroop interference[48,49] tasks. These results could indicate that affective stimuli's influence on lexical processing in alcohol dependent individuals may be different from the one occurring in healthy subjects. A plausible explanation could reside in the semantic features of alcohol related words and their complex role along the dependence process, considering their emotional and motivational properties, apparently distinct from widespread affective stimuli contemplated as natural reinforcements. Hence, the presence of this type of stimuli could have a different repercussion from general affective stimuli on Go and Stop processes, with distinct characteristics in general population. Alcohol related words' high salience, as well as their elevated incentive value[25] could, together, slower the lexical decision process through a higher cognitive resources demand when this type of stimuli are presented[1] or an abnormally increased activation of alcohol related semantic categories[3,46].

To summarize, we were able to observe that alcohol related stimuli could slower lexical information processing and interfere with Stop task correct execution, given their affective properties and high incentive value along the addiction process. Thus, behavioral inhibition, next to alcohol stimuli salience and high incentive value may play a key role in addiction processes, facilitating probable relapses.

Notwithstanding the obtained outcomes, some issues can limit results generalizations for the control group, mainly related to size sample, even though appropriate for the type of analysis set out for this study, a higher number of control subjects would allow a more profound data examination. Also, limited information was available regarding alcohol consumption pattern for this group, requiring more detailed information for a deeper understanding of the underlying processes in healthy individuals.

Eventually, considering inhibition as a substantial component of therapeutic and pharmacological interventions for alcohol dependence may result helpful for relapse number reduction and abstinence maintenance.

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CONFLICTS OF INTEREST

None of the authors have conflicts of interests with public or private entities.

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