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The Neuropsychological and Socio-cognitive variables correlated to alcohol use and abuse

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INTRODUCTION

The alcohol addiction is a complex process that involves a compulsive alcohol seeking and a harmful alcohol taking, the persistence of the consumption despite the negative consequences for the personal health and life and the possibility of relapse after long periods of alcohol abstinence. The alcohol (i.e., ethanol) alters the normal functioning of the mental processes. The effects of the alcohol on the brain functioning has been studied from different perspectives. In the present work the attention is on the neuropsychological functions (i.e., executive functions) impaired by the heavy alcohol consumption. In this case the alcohol produces a reduction of the capacity of these mental processes (Oscar-Berman & Marinković, 2007). Moreover, according to the recent Incentive Sensitization theory of Addiction, the alcohol changes (i.e., sensitized) the mesolimbic system. Repeated alcohol consumption sensitizes these brain areas and increases the salience of the alcohol-related stimuli compared to the unrelated stimuli (Robinson & Berridge, 2008).

The first chapter presents an overview of the important aspects related to the alcohol consumption. The particular attention will be paid on the harmful alcohol use and alcohol related problems with data related to the world population in general and to the Italian population in particular. In the final part of the chapter the focus will be on the process of alcohol addiction that includes the alcohol dependence and the alcohol abstinence phase in which the addiction effects are still evident, and with particular attention to the prevention and treatment aspects of the alcohol related problems.

In the second chapter will be presented a study on the cognitive deficits associated to the harmful alcohol use that are reversible after a period of alcohol abstinence. The focus will be on the neuropsychological functions that are more vulnerable to the harmful alcohol use and the effect of the alcohol abstinence on these components. Therefore, the set of cognitive abilities (i.e., executive functions) will be tested in a group of alcohol dependent participants at a very beginning of their clinical treatment and after six months of the alcohol abstinence.

The third chapter of the present work will take into the exam the long term modifications (i.e., incentive sensitization) of the mesolimbic system related to the alcohol use. The focus will be on the underlying processes of the alcohol induced

modification (i.e., the alcohol wanting and the alcohol liking) and their association with the attention toward the alcohol related stimuli. Three studies will be conducted in order to test the association between the alcohol wanting and the alcohol liking, and the salience of the alcohol related stimuli. Each study will test this association with a group of participants that consume alcohol but differ in the alcohol consumption's experience (i.e., ex alcohol addicted group, alcohol dependent group and moderated drinkers group).

CHAPTER 1

THE EPIDEMIOLOGY OF ALCOHOL

1.1 Current issues on the alcohol related problems

The alcohol consumption represents an element of social gathering and sharing in many cultures around the world. Nevertheless, considering the proprieties of alcohol as a substance and different patterns of drinking behavior, the alcohol consumption is associated to an increase risk for the health of the consumer and for the negative effects on the relevant areas of a person's life (e.g., family, employment and social relationships).Thus, it is important to analyze the effects of the alcohol in order to better understand the use and abuse of this substance that could lead to the alcohol related problems and addiction (Rehm, Kanteres&Lachenmeier, 2010).

The alcohol (i.e., alcoholic beverage) contains ethanol that can be defined as a psychoactive (i.e., psychotropic) substance that alters the functioning of mental processes like perception, memory, attention and emotion (Berman and Marinković, 2007). Moreover, alcohol is considered, in most countries (e.g., Italy), a licit or legal drug, meaning that the production, distribution and use of alcohol is allowed and controlled by the low. As a legal substance it is present in everyday life and it is highly accessible for the consumer (Anderson et al., 2006).The data on the alcohol consumption usually has been expressed using as an index, the amount (i.e., liters) of pure alcohol (i.e., ethanol) per capita consumed in a year or grams of pure alcohol consumed in a day (World Health Organization, 2014). Considering the global picture presented by the World Health Organization, that takes into account the Member States, in the 2010 the population over 15 years old consumed an average of 6.2 liters of pure alcohol (i.e., ethanol) per capita, that is 13.5 grams of pure alcohol per day. Furthermore, the data indicated that the European Region (i.e., EUR) occupies the first place based on the amount of alcohol consumed during the 2010, with 9 liters of pure alcohol per capita, followed by the Americas (i.e., AMR) with 7.2 liters (Figure1.).

The data on the alcohol consumption in Italy during the period from 2009 to 2012 indicated that 55.6 % of the population consumed at least one unit of alcohol (i.e., 12 grams of ethanol) during the past 30 days (Sistema di Sorveglianza PASSI, 2013).

Moreover, 63% of the Italian population consumed at least once an alcoholic beverage during the 2014. The North East is the Italian region with the highest level of alcohol consumption with 78.3% of male and 56.3% of female drinkers, followed by the islands (i.e., Sicily and Sardinia) with 74.3% of male and 45% female drinkers (ISTAT, 2015).

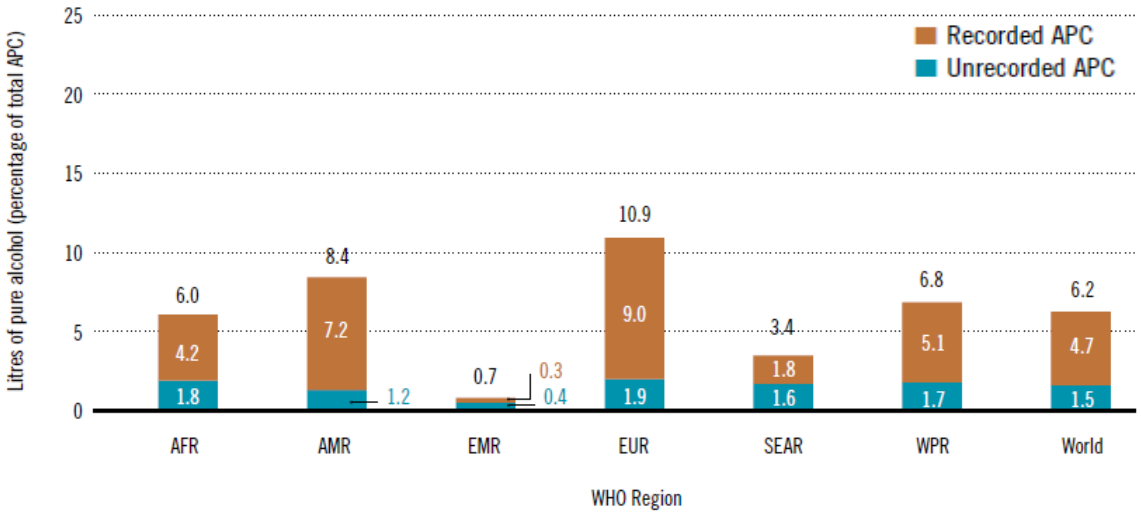

Figure1. Recorded and Unrecorded liters of pure alcohol per capita (i.e., APC) for WHO region and the world in 2010, (WHO, 2014).

As previously mentioned the alcohol is considered to be a legal drug and the consumption can lead to the development of risky drinking behavior. Thus alcohol drinking behavior can follow different patterns that can vary between individuals, based on their social and demographic characteristics, the culture or even the age and the gender (Robinson and Berridge, 2008). Importantly, different patterns can be present within a person and in that case we can observe a transition from occasional drinking to an increased consumption that often leads to the alcohol related problems and the alcohol dependence (Helzer, 2006). The first concept, related to alcohol drinking patterns, is the alcohol abstinence that indicates a condition in which a person does not consume alcohol in the present nor did consume alcohol in the past (i.e., never consume alcohol). Moreover, the abstinence also indicates a condition in which a person does not consume alcohol in the present but in the past consumed and/or had alcohol related problems (i.e., former drinkers) (Rehm, 2006).

Considering the two categories related to abstinence and current drinkers, the data of the World Health Organization (Figure 2.) indicated that almost half of the world population (48.0%) is considered to be completely abstinent (i.e., never consume alcohol), 38.3% are current drinkers and 13.7% are former drinkers (i.e., abstinent at the present). Once again, Europe is the region with most current drinkers (66.4%), considering a population older than 15 years, 20.6 % never dinks alcohol and 13.0% are abstinent at least for the last 12 months. In Italy 25.7% never consumed alcohol against 32.4% that had the experience of alcohol consumption but at the present are abstinent. Moreover, in Europe, the number of current drinkers among adolescents is the highest among other states. Considering the range between 15 and 19 years, 69.5% of the young population drinks alcohol and only 15.9% is abstaining completely (WHO, 2014).

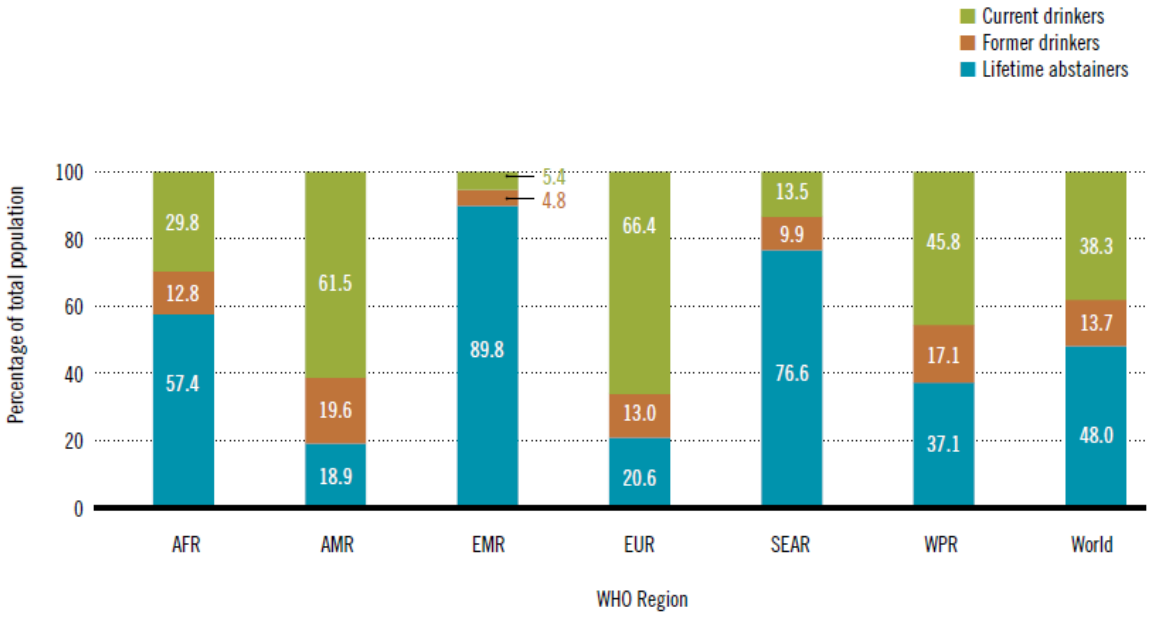

Figure 2. Proportion (%) of Current drinkers, Former drinkers and lifetime Abstainers for WHO region and the world in 2010 (WHO, 2014).

The drinking pattern is derived from a combination of elements that includes the quantity, expressed in grams or liters of pure alcohol, and the occasion in which the consumption occurs (Rehm et al., 2004). Thus, it is possible to establish the combination of high levels of alcohol and the frequency of consumption. Namely, a person can consume the same amount of alcohol in one single occasion, that is the

heavy drinking episode (i.e., more than 60 grams for man and 30 grams for woman of pure alcohol in one occasion at least once a month) or a person can consume that same amount in more than one occasion (e.g., drinking during a meal). The implications for the health of these two forms of consumptions are not the same. The heavy drinking episodes are considered to be a highly risky pattern for the health of the consumer and the probability to engage in alcohol related problems (Rehm, 2003). The data from the World Health Organization showed that in 2010, in Europe, 22.9% of current drinkers experienced heavy drinking episodes, the highest percentage among the other regions involved in the survey (WHO, 2014).In Italy the 4.3% of the tested population of current drinkers experienced the same drinking pattern (Sistema di Sorveglianza PASSI, 2013). Recent data indicated that in 2014, 10% of man and 2.5% of woman engaged in heavy drinking behavior in Italy (ISTAT, 2015).

Not all alcohol consumers develop alcohol related problems or alcohol dependence. There are several factors, including the drinking pattern, that make certain groups of people more vulnerable to the negative effects of the alcohol. One of these factors is the difference by age in alcohol consumption. Before the age of 21 the human body is not fully capable of metabolizing the alcohol and it is completely incapable before the age of 16. Moreover, in adults over 65 years the metabolic capacity in processing alcohol declines significantly (Berman and Marinković, 2007). In a young population (i.e., adolescents of15-19 years), an increase risk is represented by the frequent heavy drinking episodes, namely younger people tend to consume alcohol in a more intense way but in one single occasion. On the other side, in older population a quantity of alcohol tends to be more constant and frequent (Sorock, Chen, Gonzalgo and Baker, 2006).Considering the adolescent population and the adults (i.e., 15 and older) on a world scale, in 2010 the 11.7% of the young population showed a heavy drinking pattern compared to a 7.5% of adults. Moreover, in Europe the 31.2% of the young population engaged in heavy drinking episodes against 16.5% of the adult population (Figure 3.). Among Italian adolescents the heavy drinking behavior is present in 29.9% of the young population (WHO, 2014).The data from the 2014 regarding the age differences in alcohol consumption in Italy indicated that 90% of the population under 15 years old did not consume alcohol, but the data changed significantly when the 16 years old population was considered (43.4% drinkers). The alcohol consumption tended to increase with the age, so that 62.5% of young people within the range of 18-19 years

old consumed alcohol and the highest percentage was found within the population of 25-29 years old (72.7% drinkers). On the other hand, considering the adult population of 65 years and older, 52% consumed alcohol every day during the 2014, confirming a tendency of the adult population to consume alcohol in constant doses but more frequently (ISTAT, 2015).

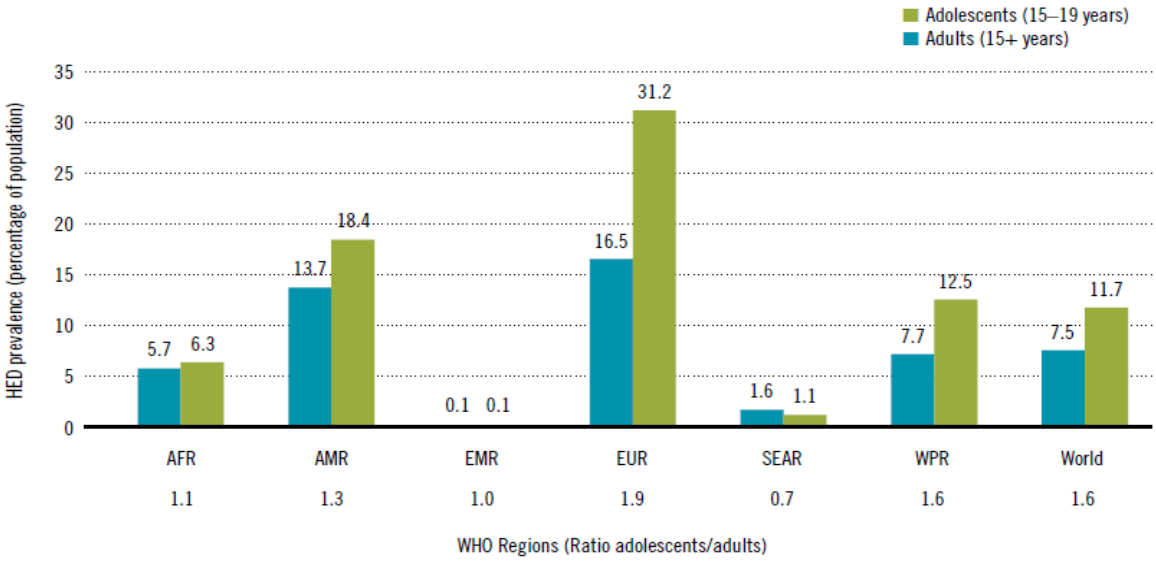

Figure 3.Heavy drinking episodes (%) in adult population (15 years and older) and in adolescents (15-19 years) for WHO regions and the world in 2010 (WHO, 2014).

Another relevant factor, considered as an indicator of vulnerability to alcohol related problems, is the gender. Man and women differs in their drinking patterns and in their vulnerability to alcohol related problems. Women tend to be more vulnerable to alcohol effects because of physical characteristics, for example a lower body mass and less liver capacity in metabolizing the alcohol, factors that contribute to achieve faster high blood concentration of alcohol, compared to man (Wilsnack and Wilsnack, 2013). Nevertheless, evidence indicates that males are more at risk regarding the alcohol. Considering the world population older than 15 years, in 2010, the 47.7% of current drinkers were males and 28.9% were females. The alcohol drinking pattern, in particular the heavy drinking episodes were present in 21.5% of males and 5.7% of female current drinkers. The gender differences in drinking pattern also emerged in Europe, 2.0% of man experienced heavy alcohol drinking episodes compared to 0.5% of woman. In Italy the same drinking pattern was present for 9.8% of male current drinkers and for 1.3% of

female drinkers (WHO, 2014). Taking into a count only the Italian territory in 2014, the North East was the region with most male current alcohol drinkers (78.3%) and most female current drinkers (56.3%). Importantly, among these current drinkers 34.8% of males and 13.6% of females drank alcohol every day of the year (ISTAT, 2015).

The alcohol drinking pattern is an indicator of a hazardous or harmful consumption of this substance. As previously mentioned, this behavior is correlated to many negative factors associated to the health of the consumer, the social relationships, the economic status and other relevant areas of a person's life (Stranges et al., 2006). In 2012 the alcohol use caused 3.3 million of deaths, namely 5.9% of all deaths was associated to the alcohol consumption (World Health Organization, 2014). The problems for the health of a consumer involve approximately fifty different diseases and other body injuries (Rehm, Room, Graham, Montiero, 2003). A survey conducted in 2012 categorized health problems based on the percentage that is attributable to the harmful use of alcohol. Thus, alcohol is associated at 100% to alcohol use disorders (i.e., AUD) and fetal alcohol syndrome, while 50% of liver cirrhosis is associated to alcohol consumption. Moreover, 22% of interpersonal violence and self-harm and 15% of traffic injuries can be attributed to the use of alcohol. Considering the consequences of the alcohol consumption for the health and the association with the mortality levels, in 2012 was estimated that 5.9% of world's deaths were attributable to the alcohol. Once again the Europe was the region with the highest percentage of deaths associated to alcohol consumption (13.3%) followed by the Western Pacific Region (5.9%) and the Americas (4.7%)(Figure 4.).In Italy in 2011 the number of deaths due to health problems completely attributable to the alcohol was 1543, 1210 of males and 333 of female's deaths (CNESPS, 2015).

Besides the health problems (i.e., disease) related to alcohol use, another relevant implication of the alcohol consumption is represented by the traffic injuries. Research conducted on the effects of the alcohol blood concentration on the driving skills showed that particular abilities involved in driving, like motor planning, goal directed actions, monitoring and memory are significantly impaired due to the alcohol consumption (Meda et al., 2009, Moskowitz, & Fiorentino, 2000). During the period from 2009 to 2012, in Italy, 10% of drivers declared that they drove a vehicle one hour after they had consumed one or more alcohol units (i.e., 12 grams of pure alcohol or more) at least once in the past 30 days. Moreover, 7% of the population claimed that

they have been in a vehicle driven by a person that was under the effect of alcohol. Moreover, the data on the single Italian regions indicated the North East (e.g., Friulli Venezia Giulia 13%, Piemonte and Veneto 11%) on the first place for driving after drinking. The younger population is more at risk from this type of injuries. Namely, in Italy the risk for traffic injuries is significantly higher for the population between 25-35 years old (Sistema di Sorveglianza PASSI, 2012).

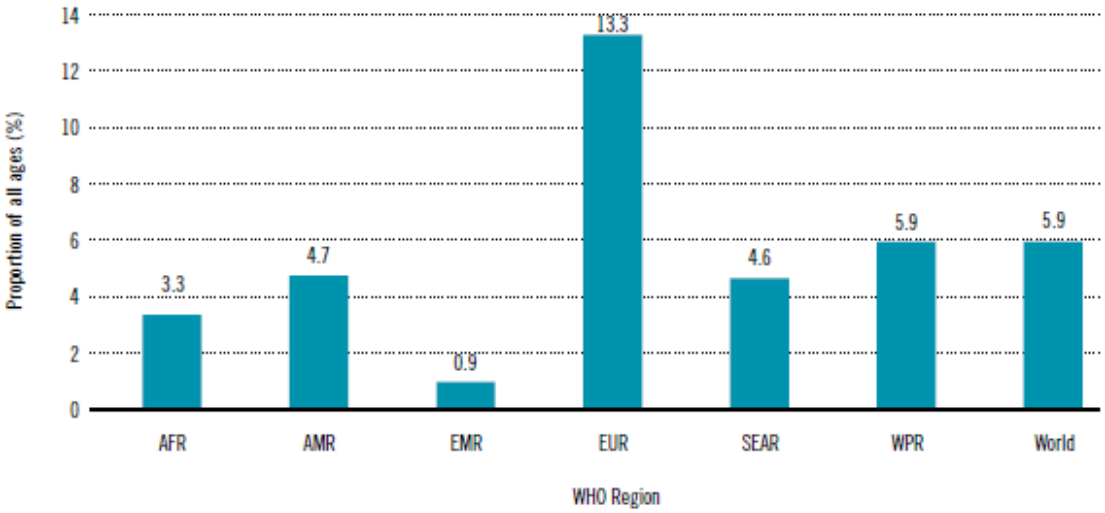

Figure 4.Percentage of the deaths attributable to the alcohol consumption for WHO regions and the world in 2010 (WHO, 2014).

As previously mentioned, alcohol related patterns of consumption can lead to a development of alcohol use disorders. First of all, there can be consequences for the physical health (e.g., liver cirrhoses and heart problems) and for the mental health (e.g., memory and attention) (Anderson, & Baumberg, 2006). Moreover, a consumer can develop the alcohol dependence. The alcohol dependence involves a compulsive seeking and taking of the alcohol and impaired capacity to control the alcohol intake (Nestler, 2001), a high tolerance and negative physical effects (i.e., withdrawal) of the alcohol and the persistence of the consumption despite the negative consequences for the health and the living context (DSM-V, 2015).The prevalence of alcohol use disorders (Figure 5.), which includes alcohol dependence, in Europe in 2010 was 7.5% (4.0% was alcohol dependent). In Italy, in the same period, 1.0% of the population had

alcohol use disorders and 4% were alcohol dependent. Once again, the male population was more vulnerable (1.3%) than female (0.8%) for alcohol use disorder and a difference was also found for the alcohol dependence (0.7% for males and 0.4% for females) (WHO, 2014).

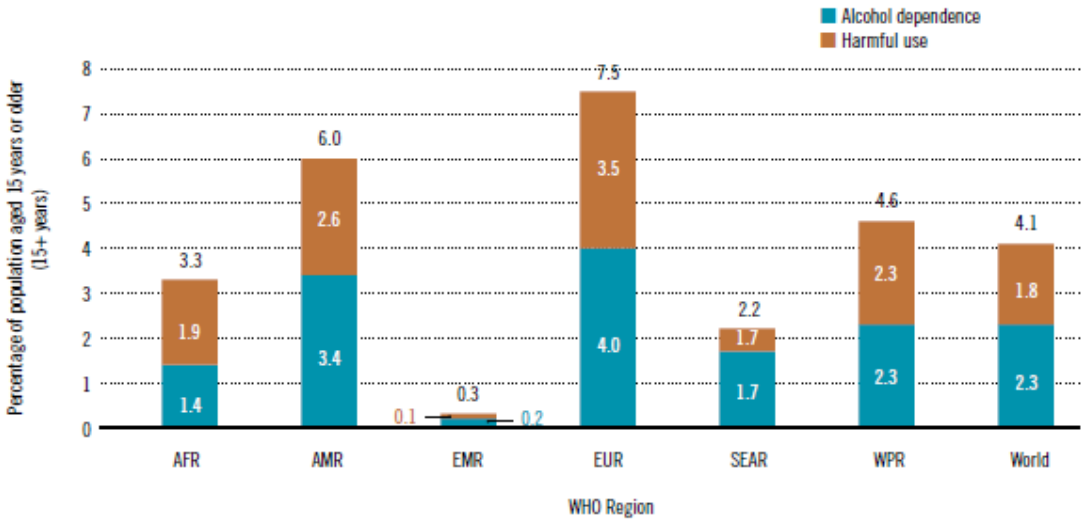

Figure 5.The proportion of the harmful use of the alcohol and alcohol dependence in a population of 15 years and older for WHO regions and the world in 2010 (WHO, 2014).

The limits for the harmful use of alcohol are separate for man and woman. For man the limit for harmful alcohol consumption is equal to 60 grams of pure alcohol per day, while for woman the same limit is lower (40 grams of pure alcohol). In Italy during the 2012, 400 000 males (older than 11 years) consumed more than 5 alcoholic drinks per day (one drink contains an average of 12 grams of pure alcohol), crossing the limitation for harmful consumption. Moreover, the female population of 220 000 drank more than 3 alcoholic beverages during the same period (CNESPS, 2014). A survey conducted in Italy from 2009 to 2012 indicated that 6.2% of the tested population received a doctor recommendation to reduce the alcohol consumption because it was considered to be harmful (Sistema di Sorveglianza PASSI, 2013). Importantly, in 2014, 8 million 265 thousand persons in Italy crossed the limit for harmful alcohol use that can lead to alcohol associated disorders (Osservatorio Nazionale alcool, 2015).

1.2 Alcohol related problems and dependence: implications, treatment and prevention

The harmful alcohol use has relevant implications for the personal health (e.g., alcohol related diseases, injuries, alcohol use disorders and addiction), for the health of others (e.g., traffic injuries) and for the public health (e.g., mortality levels associated to the harmful use of alcohol).As previously mentioned, the alcohol addiction is a process that forms in time and within we can observe a transition from the harmful alcohol consumption to the alcohol dependence (Robinson and Berridge, 2003). Considering that the alcohol related problems represent the harmful uses of alcohol and dependence, these two concepts are highly correlated (DSM-V). Altogether, these factors contribute to an increased attention for the appropriate and early identification of the alcohol related problems. Moreover, given the fact that a harmful use of alcohol manifests trough psychological symptoms (e.g., compulsive alcohol seeking) and physical symptoms (e.g., tremor, nausea, muscle cramps and liver damage), the first relevant information related to the risk of developing this type of problems could be identified by the personal physician. The physician can evaluate the clinical symptoms that indicate the risky behavior (Marlatt, Witkiewitz, 2002). However, the specific evaluation of the alcohol related problems and the appropriate treatment are addressed to the Department for legal drug's addictions. Based on the clinical observations, the World Health Organization indicates that 620 000 – 720 000 individuals older than 11 years present alcohol dependence problems. During the 2012, in Italy it was estimated that 69 770 individuals should have contacted the Department for legal drug's addictions, based on their clinical symptoms, but only 49 147 received the clinical treatment. Thus, 20 623 individuals presented symptoms in line with the alcohol dependence problem but did not receive any treatment (CNESPS, 2014).

One of the factors responsible for the discrepancy between the observed and the expected numbers of alcohol dependence's treatment is given by the social representation of the alcohol related problems and dependence. Although the alcohol consumption is considered to be socially acceptable and it is promoted in many occasions of social gathering (e.g., toasting at special occasions), the alcohol dependence has been strongly stigmatized (Room, 2005). By stigmatizing a group of individuals in general and alcohol dependent individuals in particular, that group is

considered to be different based on the negative aspects (e.g., behavioral and health problems related to alcohol) and activates some negative attitudes (e.g., avoidance, exclusion from social acceptance) (Sample, Grant, Patterson, 2005).Moreover, the alcohol dependent individuals also stigmatize the own alcohol dependence condition. Altogether, the stigmatization by others and by the self lead to the negative consequences (e.g., depression and lower self-esteem) and importantly, a dependent person tend to reject or postpone the request for help from a professional or a relevant other (Schomerus et al. 2010, Sobell et al., 2000). In order to reduce the damage of the alcohol dependence and the negative effects of the alcohol related stigmatization it is important to offer programs that allow a professional help with the possibility of the complete anonymity (e.g., telephone, books, internet and groups for support)(Marlatt, & Witkiewitz, 2002).

Beside the professional treatment of alcohol related problems, there are several types of organizations for the support of the alcohol dependence treatment that facilitate the recovery program and contribute to the reduction of the negative effects of the alcohol related stigma. These groups represent the non professional and peer support organizations that base their work on the exchange of experiences and advices regarding the addiction problems. The studies conducted on the group support found an increase period of alcohol abstinence and the improvement in social functioning of the addicted individuals. Moreover, the efficacy of the group support is increased when there is collaboration with the professional treatment (Humphreys et al., 2004).

In order to understand and contrast the implications of the alcohol related problems and alcohol dependence, different organization collaborate on the prevention and the early identification of these category of problems. In Italy, one of these collaborations is formed between ISS (i.e., IstitutoSuperiore di Sanità), the Ceformed (FriulliVenezia Giulia), the Cergas (Bocconi) and the University of Sheffield. The program proposed for the early identification and intervention of the alcohol related problems involves the primary care services. Moreover, the program is based on the collection of the data related to the morbidity, mortality and the recovery in the primary care setting. There are two propositions with different costs and time schedule but with the common goal and the same outcome that is, the screening of the patients, within the primary care, for alcohol dependence symptoms. If applied, this program can increase the probability for a correct and early identification of patients at risk in one case to

58% and in the other case even to 96% of correct identifications (CNESPS, 2015).One of the screening instruments available and largely used in the primary care is the Alcohol Use Disorders Identification Test (i.e., AUDIT). The AUDIT is a 10 item questionnaire that allows us to identify the risky alcohol behavior and the level of the alcohol consumption (e.g., hazardous or harmful use and alcohol dependence) (Babor, Biddle, Saunders, & Monteiro, 2001). Moreover, it is possible to combine the AUDIT with other scales in order to collect specific data on the alcohol consumption behavior, like the C.A.G.E. questionnaire. The C.A.G.E. is a 4 item scale that indicates 4 elements that could indicate alcohol dependence problems: the cut down on drinking, the warnings from others on the drinking behavior, feelings of guilt and the hazardous drinking pattern (Ewing, 2004). These screening tests are indicators of risky alcohol consumption and of the presence of elements corresponding to a clinical picture of alcohol dependence. Thus, the use of these questionnaires should be to identify on time patients that are at risk but a more specific diagnoses is always needed.

Given the implications of the harmful use of the alcohol and the costs for the health services, there are different alcohol policies and intervention programs that change from state to state, having as a common goal a regulation and reduction of the consequences correlated to the alcohol use and abuse. The difficulties regarding the regulation of the alcohol consumption are represented by the fact that alcohol is, in most countries, a legal substance. Thus, the interventions are focused on limitations of its distribution, selling and advertising, rather than on a prohibition of its consumption (Anderson et al., 2006). As previously mentioned, the alcohol is easily accessible for the consumer, therefore the regulations implies limitations of days and hours of alcohol selling and a legal limit on age for purchasing and consumption of alcohol (Elder et al., 2007).

Based on the data of 2012, in Europe, 18-20 countries (i.e., for beer 18, for wine 19 and for spirits 20 countries) had a regulation of the hours of alcohol selling and Italy is among them. Moreover, only 6 European countries had regulated the days of alcohol selling and Italy is not among them. For most countries, including Italy, the age limit of purchasing and consumption of alcohol is established at age 18, for fifteen countries the limit is at 16 years and for fourteen countries the age limit of consumption is fixed at 21 years. Another important policy is the one regarding drinking and driving condition and the allowed blood concentration for a driver. For most countries the limit of the

concentration is below 0.05%. In Italy, the limit of alcohol concentration in blood is 0.05%, while in the USA has a limitation range of 0.08-0.15%. In some cases a country choose a zero tolerance policy like Russia (WHO, 2014).

The alcohol use, in particular the harmful use, has many implications for the individual, the relevant others and the public system as well. The alcohol dependence and the alcohol addiction need to be better understand in order to be able to prevent this condition and to be able to propose recovery solutions for the alcohol addiction problems.

CHAPTER 2

NEUROPSYCHOLOGICAL IMPLICATIONS OF THE ALCOHOL

2.1 On the executive functions in alcohol dependent individuals

The alcohol (i.e., ethanol) is a psychoactive substance that produces different effects on the human body. As described in the previous chapter, the harmful alcohol consumption is associated to a number of diseases (i.e., liver cirrhosis and fetal alcohol syndrome) and to a series of negative effects on the components of the nervous system (Oscar-Berman, & Marinkovic, 2007). In fact, the heavy alcohol drinking affects the neurological processes having as consequences the decrease of the temperature regulation (Danel et al., 2001), the alteration of the sleep pattern (Singleton and Wolfson, 2009) and the loss of the muscle's strength (Vary and Lang, 2008). Furthermore, the harmful alcohol use and the alcohol intoxication (i.e., acute effects of the ethanol consumption) could lead to a damage of the brain (Moselhy et al., 2001). It is important to specify that not all alcohol users are at risk for brain damage related to this substance. Studies demonstrated that the category at risk for neuropsychological deficits is the heavy drinking part of the population (Bartsch, 2007, Ende, 2005, Shaw et al., 2006). In particular, studies conducted with the MRI on the association between alcohol consumption and the brain areas, identified the frontal lobes as the region that is particularly affected by the chronic use and abuse of this substance (Dirksen et al., 2006, Oscar-Berman et al., 2004, Pfefferbaum et al., 1997). Moreover, in alcohol dependent individuals, the fMRI showed evidence of brain dysfunction and reduced blood flow in the frontal lobes (Tapert et al., 2001, Gansler et al., 2000).

The frontal lobe is the largest cortical region in the brain that is associated to a variety of neuropsychological functions like planning, decision making and response control (Moselhy et al., 2001, Noel et al., 2001). In the present chapter is focused on the functions that are more vulnerable to the effects of the harmful alcohol consumption, namely the executive functions (Moselhy et al., 2001). The executive functions represent a set of cognitive abilities which includes the cognitive flexibility (i.e., ability to switch between sequences) (Loeber et al., 2009), the visuo-motor co-ordination (Cubillo et al., 2009), the fluency (Serrano, 2009), the inhibition/interference control

(Salthouse, 2003) and the working memory components (Finn et al., 1999). In particular, studies conducted on the deficit of these functions and the alcohol abuse, indicated that the alcohol dependent individuals present a more extended impairment of the cognitive flexibility, the verbal fluency, the motor speed and the working memory compared to the occasional alcohol users (Pitel et al., 2009, Streeter et al., 2008, Chanrand et al.2007, Verdejo-Garcia and Perez-Gracia, 2007).

The alcohol abuse and dependence are associable to the long lasting impairment of the executive functions (Moselhy et al., 2001). Nevertheless, these cognitive deficits are potentially reversible trough a period of alcohol abstinence (Moselhy et al., 2001). Studies conducted with hospitalized alcohol dependent patients indicated a change in the performance on measures of short-term memory, abstract reasoning, spatial ability and visuo-motor co-ordination during only two weeks of alcohol abstinence (Reed et al., 1992). Other studies with alcohol dependent participants found a persistent impairment of the cognitive flexibility and the inhibition/interference capacity after almost a year of abstinence (Ratti et al., 2002, Noel et al., 2001). Moreover, the working memory has been more resistant to the recovery period even after months of treatment (Mann, 1999).

The main aim of the current study is to exam the effect of the period of abstinence on the neuropsychological functions that are more vulnerable to the harmful use of alcohol within a group of heavy alcohol-use individuals. Therefore, we measure the verbal fluency, the cognitive flexibility, the visuo-motor co-ordination and the working memory capacity in two sessions (i.e., Time 1 and 2). In order to assess these neuropsychological variables we use a set of tests frequently administrated with patients with frontal lobe lesions (Cubillo, 2009, Stuss et al., 2001, Trayer et al., 1998, Baddeley et al., 1997). The verbal fluency is assessed with the Phonemic and Semantic versions of the test. This test require from the participant to produce as many words as possible given the specific cue (i.e., alphabet letter and the word category) and under a specific rule (i.e., no personal names and derived words) (Troyer et al., 1998). The Trail Making test parts A and B are use to assess the mental flexibility intended as the ability to switch the task set when is required and the visuo-motor speed. In particular, the A version (i.e., follow a number sequence) of the test is more simple compared to the B part and requires a visuo-motor ability and number recognition. The part B of the task is presented after the A part and increases in complexity, measuring the visuo-motor speed

(as for the A part) but also the mental flexibility in managing more stimulus at the time and shifting of the set (i.e., shifting between number and letter's sequences) (Cubillo et al., 2009). The Digit Span test (i.e., forward and backward version) is used to measure of the working memory capacity. Thus, the digit span is used to assess the capacity to maintain the information in the short-term memory (i.e., Digit Span forward) and the capacity to manipulate the information in memory (i.e., Digit Span backward) (Finn et al., 1999). The single tasks' structures are explained in the Procedure section of the chapter.

The main hypothesis is that the prolonged period of alcohol abstinence should produce e reduction of the impairment of these functions. Thus, the performances on the neuropsychological measures should be significantly different between the first session of the study (i.e., Time 1) and the second session of the study (i.e., Time 2) after e period of 6 months of alcohol abstinence. Therefore, the performance on the single neuropsychological tests should be superior in the second session of the study (i.e., Time 2) compared to the first session of the same study (i.e., Time 1). In order to control the period of abstinence, we choose a group of alcohol dependent individuals that were at the beginning of the recovery program and that would attend the program for the months that followed the first session of the study. The program was based on the complete abstinence from alcohol and in daily therapy with group sessions in order to support the transition from alcohol dependence to alcohol abstinence.

2.2 Study

2.2.1 Participants. Forty seven individuals (N = 26 males, N = 21 females, M age = 50.98, SD = 11.3) that were entering the recovery program for alcohol dependence problems at the Department for legal substance's addiction (i.e., Dipartimento per le dipendenze da sostanze legali, Trieste, Italy) voluntary participated to the first session of the current study (i.e., Time 1). The participants had an average of 11.36 (SD = 3.45) of school education years and 9.68 (SD = 10.62) years of alcohol consumption experience.

2.2.2 Procedure. In the first session (i.e., Time 1), all participants completed two questionnaires, The Alcohol Use Identification Test (i.e. AUDIT, Babor, Higgins-

Biddle, Saunders, & Monteiro, 2001) and the C.A.G.E. (Ewing, 2004) in order to assess the harmful use of alcohol and the elements of alcoholism, respectively. The two questionnaires were presented in the counterbalanced order. The set of neuropsychological tests included: the Phonemic Verbal Fluency test and the Semantic Verbal Fluency test (Novelli, Papagno, Capitani, Laiacona, Vallar, & Cappa, 1986), the Trail Making Test Parts A and B (Reitan, 1958), and the Digit span forward and backward tests (Wechsler, 1987).

The Phonemic Verbal Fluency test was used to assess the ability of the participants to generate words given a specific cue (i.e., Phoneme).The participants were asked to verbally produce words that begun with the specific phoneme (i.e., alphabet letter) within a time limit. The rule stated that words could belong to any word category, with the exception for proper names and no derived words (e.g., friend-friendly). Thus, all participants received instructions to produce as many words as possible that begun with the letters "C", "P" and "S". A time limit of 1 minute was given for each cue (i.e., letter). The number of correct words produced for each letter in one minute was obtained.

The Semantic Verbal Fluency test was used, as the previous test, to measure the ability of the individuals to produce words given a specific cue (i.e., Category).The test followed the same procedure of the Phonemic Verbal Fluency test. The participants were asked to produce words that belong to specific semantic categories of "Vehicles" and "Animals" within the time limitation of 1 minute for each cue (i.e., category). The number of words produced for each category within the given time was calculated. The Semantic Verbal Fluency test was presented to all participants after the Phonemic Verbal Test in order to control the influence on the words' selection strategy.

The Trail Making Test Parts A and B were used to assess the visual and motor speed and the mental flexibility. Each part had 25 items that consisted of circled numbers and the combination of numbers and letters, for the Part A and B respectively. The items were distributed over a sheet of paper (210 x 297 mm). The Trail Making Test Part A measured the visual capacity and motor speed of the participants (Appendix). The test consisted of drawing a line (i.e., trail) in order to connect the numbers from 1 to 25 in the ascending order. The participants were asked to connect the numbers in the ascending order as quickly as possible and without lifting the pen from

the sheet of paper. Before the test, participants were given the instructions and the practice version which included items from 1 to 8. If the practice version was completed correctly the participant could proceed with the task.

The Trail Making Test Part B (Appendix) measured the psychomotor speed, the ability and set shifting in the organization of more stimuli. The test followed the same procedure of the Part A. The difference from the previous test consisted in the addition of the letter sequence. Therefore, all participants received instructions to connect with the line (i.e., trail) all the items on the paper, but this time they were asked to alternate to each number in the ascending sequence (i.e., from 1 to 13) a letter in the alphabetic order (i.e., from A to L). As in the previous part of the test, the practice version was given to all participants with numbers from 1 to 4 and letters from "A" to "D" (e.g., practice sequence 1-A-2-B-3-C-4-D). If they completed the practice correctly, the Part B was administrated. The order of the presentation of the Trail Making Parts A and B for all participants was the same (i.e., from A to B). The time taken to complete the trail and the number of errors was measured for both parts (i.e., A and B) separately.

The Digit span forward test was administrated in order to measure the capacity to maintain specific information in the short-term memory. The task consisted of 7 items (i.e., numbers sequences) that differed in the digits combination (e.g., 2-8-6-1, 5-3-9-4) and the sequence's length (i.e., increasing length). The number's sequence had been read to the participants, pronouncing one digit per second. The participants had to verbally repeat immediately the complete sequence in the correct order of presentation. Before the task, each participant was administrated a practice version that consisted of two numbers (i.e., 7-9). With each sequence the length increased for one digit. If the participant failed to repeat correctly the sequence (e.g., 7-4-2-9-6) the second sequence of the same length was read (e.g., 8-5-1-6-4). The shortest sequence contained 4 digits and the longest contained 10 digits. If the participants completed the trial correctly the task continued with the next longer sequence, otherwise the task ended.

The Digit span backward test was used in order to assess the capacity of the manipulation of the information in the short-term memory. The test shared the same procedure and the number of items as the forward's version. The backward task differed from the previous version in the fact that participants were asked to recall the digits' sequence in the reversed order (e.g., hear 7-5-1, repeat 1-5-7). As in the previous task, a

practice trial was presented with a 3-digit sequence. The shortest and the longest sequence contained 3 and 9 digits respectively. The score (i.e., the span) for both versions (i.e., forward and backward) corresponded to the length of the longest sequence correctly recalled. The two versions of the Digit span were presented to all participants in the same order (i.e., Forward than Backward).

The order of the administration of the neuropsychological tests (i.e., the Phonemic and Semantic Verbal Fluency test, the Trail Making A and B, the Digit span test forward and backward) was counterbalanced across the participants. The materials and the procedure of the second session (i.e., Time 2) were identical to the first session (Time 1) of the present study. Between the two sessions (i.e., Time 1 and Time 2) all participants had the same recovery program.

2.2.3 Results

First session of the study (Time 1):

Audit. On the Alcohol Use Disorder Identification Test participants' obtained an average score of 24.27 (*SD* = 7.62) which was over the cut off score of 20 indicating the necessity of clinical diagnosis for alcohol dependence.

C.A.G.E.. Participants reported a mean score of 2.84 (*SD* = .98) which was above the cut off score of 2 indicating that the sample presented elements related to the alcohol dependence.

The Phonemic and Semantic Verbal Fluency test. For each participant a mean score was calculated on a total words produced for the three phonemes (C, P and S). The sample mean was 11.79 (*SD* = 4.1) words. No significant difference was found on the Phonemic fluency between man and women, $t(45) = .19$, $p = .85$. For the semantic fluency test the mean score was obtained from the total of words produced for both categories (Vehicles and Animals). The group of participants obtained a mean score of 15.1 (*SD* = 3.74). No score difference emerged between male and female participants, $t(45) = -.94$, $p = .35$.

The Trail Making Test Parts A and B. For each participant the number of seconds needed to complete the task and the total of errors were calculated for the two parts of the task separately. The participants require an average of 48.2 seconds (*SD* =

22.68) to complete the trail making test A, and an average of 121.57 seconds (*SD* = 57.9) to complete the part B of the test. Moreover, the number of errors was calculated for each part of the test. Participants tended to make more errors on the part B of the test, (*M* = 2.81, *SD* = 2.74), compared to the part A of the test, (*M* = 1.49, *SD* = 2.82), and this difference was significant, *t*(45) = -3.06, *p* = .004. In order to compare the two parts of the test, the B-A score was calculated so that a positive score indicated a higher time interval to complete the part B compared to the part A of the test. The score was analyzed by the one sample t-test (test value = 0) and indicated a significant difference, *t*(45) = 10.34, *p* = < .001, between the trail making test B compared to the A part, (*M* = 72,85, *SD* = 48.3). No difference in the performance occurred between man and women on the part A, *t*(45) = -.96, *p* = .34, and on the part B, *t*(45) = -1.47, *p* = .15.

The Digit span test forward and backward. On the Digit span test forward participants obtained a mean score (i.e., span) of 5.57 (*SD* = .85). No difference occurred between male and female participants on the task's score, *t*(45) = 1.73, *p* = .09. The mean score on the Digit span backwards was 3.87 (*SD* = 1.04). Moreover, a significant difference, *t*(45) = 2.61, *p* = .02, emerged between male, (*M* = 3.54, *SD* = *1*), and female participants, (*M* = 4.29, *SD* = .96), indicating a better performance for the female group of participants.

Correlation analyses. A correlation analysis was conducted between the sample characteristics (i.e., Age, Education and Years of alcohol consumption, AUDIT and C.A.G.E.) and the Neuropsychological measures (i.e., the phonemic and semantic verbal fluency, the trail making tests A and B, the number of errors on the trail making tests A and B and the Digit span forward and backward). The data for all correlations are presented in the Table 1-5. No significant correlation emerged between the sample characteristics and the Verbal Fluency Tests (i.e., the phonemic and semantic verbal fluency) as shown in Table 1. The Age correlated significantly with the score on the Trail Making Test part B indicating that the higher the age of the participants, the higher the number of seconds needed to complete the trail making test B. Moreover, a significant correlation emerged between the Age and the number of errors participants made on the trail making part B (Table 3.), the number of errors on the task increased with the age of the participants. The Education of the participants (i.e., years of school education) and the trail making part B significantly correlated meaning that the more years of education the less time was spent to complete the trail making test part B.

The correlation analysis between the neuropsychological measures are shown in Table 5 and revealed significant association between measures that assessed the same executive function, as indicated in the literature. Namely, the two verbal fluency tasks were correlated (i.e., Phonemic and Semantic fluency). Thus, the more words participants produce on the single phoneme test, the more words they produced for the word categories. The two Trail making measures also correlated significantly indicating that more time participants spent on the simple version of the test (i.e., part A) more time they spent to complete the next part of the test (i.e., part B). As showed in Table 5 the Digit span test forward correlated significantly with the Digit span backwards indicating that the higher the number sequence correctly recalled in the forward version the higher the number sequence correctly recalled in the reverse version (i.e., backwards version).

Table1. Correlations between the sample characteristics and the Phonemic and Semantic Verbal Fluency test

Sample characteristics	phonemic	semantic
Age	-.16	-.12
Education	.25	.13
Dependence	-.12	-.02
AUDIT	-.04	.06
C.A.G.E.	.1	.02

*$p < 0.05$, **$p < 0.001$;

Table 2. Correlations between the sample characteristics and the Trail Making Test Parts A and B and the score A-B

Sample characteristics	TMT A	TMT B
Age	.26	.4*
Education	-.2	-.37*
Dependence	-.09	-.04
AUDIT	-.03	.11
C.A.G.E.	-.15.	-.07

*$p < 0.05$, **$p < 0.001$;

Table 3. Correlations between the sample characteristics and the Number of Errors on the Trail Making Test Parts A and B

Sample characteristics	TMT A err	TMT B err
Age	.04	.38*
Education	.03	-.11
Dependence	.12	.07
AUDIT	-.25	-.24
C.A.G.E.	-.01	.14

*$p < 0.05$, **$p < 0.001$;

Table 4. Correlations between the sample characteristics and the Digit span test (backward and forward)

Sample characteristics	DS forward	DS backward
Age	-.23	-.09
Education	.25	.2
Dependence	.11	.11
AUDIT	-.02	-.07
C.A.G.E.	.04	.18

*$p < 0.05$, **$p < 0.001$;

Table 5. Correlations of the neuropsychological measures

	1	2	3	4	5	6	7	8
1 phonemic	_							
2 semantic	.71	_						
3 TMT A	-.3*	-.32*	_					
4 TMT B	-.32**	-.23	.58**	_				
6 TMT A err.	-.12	-.07	-.001	-.009	-.01	_		
7 TMT B err.	.02	.12	.22	.49**	.48**	.43**	_	
8 DS forward	.23	.16	-.3*	-.31*	-.24	.08	-.17	_
9DS backward	.16	-.02	-.31*	-.21	-.1	.00	-.13	.43**

*$p < 0.05$, **$p < 0.001$;

Second session of the study (Time 2):

Twenty participants (N = 11 males, N = 9 females; age M = 50.65, SD = 8.33) completed the second session (i.e., Time 2) of the present study administrated after a period of 6 (M = 6.94, SD = .99) of the recovery program. Considering the sample (N = 47) of the first session (i.e., Time 1) the 42.6% of the participants repeated the neuropsychological tests while 56.3% did not participate to the second administration. Considering the group of participants that did not take part to the Time 2 (N = 27) indicated that the 33.3% of the group went into the relapse and did not proceed the recovery program, and the 66.7% were out of reach at the time. The characteristics of the participants that repeated the testing session and the participants that did not repeat the same session were compared by means of the independent sample t-test. The two groups of participants did not differ based on Age, $t(45) = .87$, $p = .57$, Years of alcohol use, $t(45) = .24$, $p = .82$, AUDIT score, $t(45) = -.35$, $p = .73$, and C.A.G.E. score, $t(45) = .56$, $p = .58$. The only difference is related to the years of education, $t(45) = -2.83$, $p = = .007$, indicating that the participants at Time 2 had more years of education, (M = 12.9, SD = 2.95), compared to the other group, (M = 10.22, SD = .39). As for the neuropsychological variables, no statistically significant difference emerged between these two groups of participants on the Phonemic test, $t(45) = .75$, $p = .97$, on the Semantic test, $t(45) = -.23$, $p = .82$, on the Trail Making part A, $t(45) = .52$, $p = .6$, on the Trail Making part B, $t(45) = -.35$, $p = .73$, on the Digit span forward, $t(45) = -.18$, $p = .86$, and on the Digit span backward, $t(45) = -1.01$, $p = .32$. Thus, it is possible to consider the participants of the Time 2 session as representative of the original sample (Time 1).

Comparison of Time 1 and Time 2 sessions:

Each paired sample t-test were conducted in order to compare the results on the single neuropsychological tests between the first (Time 1) and the second (Time 2) session of the study. The Phonemic verbal fluency test showed no difference between the two sessions, $t(19) = -.15$ $p = .88$), indicating that there was no difference in the number of words produced on the single phoneme's rule between Time 2 (M = 11.88 (SD = 2.8) and Time 1 (M = 11.77, SD = 4.19). On the Semantic verbal fluency test participants in the second session obtained a mean score of 15.55 (SD = 3.72) but this score did not differ significantly, $t(19) = -.55$ $p = .59$, from the first session (M = 14.95,

SD = 3.9), therefore the number of words for the categories did not differ for this group of participants between the two sessions . The results on the Trail Making Test Part A showed no significant difference in the time that participants spent to complete the task, $t(19) = 1.41$ $p = .18$, between the Time 2 ($M = 43.8$, $SD = 16.74$) and the score obtained in the Time 1 ($M = 50.75$, $SD = 23.64$). However, the analysis on the number of errors made on the part A of the test indicated a significant difference, $t(19) = 3.08$ $p = .006$, for the participants' accuracy (i.e., number of errors) in Time 2 ($M = .25$, $SD = .72$) compared to Time 1 ($M = 1.25$, $SD = 1.12$).

A significant difference on the test scores between the two sessions of the study emerged on the Trial Making Test B, $t(19) = 2.62$ $p = .02$), indicating that the time participants spent to complete the part B of this test in Time 2 ,($M = 93.4$, $SD = 29.92$), significantly differed from the time needed to complete the same task in Time 1 ($M = 118.1$, $SD = 58.44$). Moreover, the difference in the accuracy on the part B of the task in the Time 2 ($M = .9$, $SD = 1.12$) significantly differed, $t(19) = 4.19$ $p = .001$, from the Time 1 score ($M = 3.15$, $SD = 2.8$). The score on the Digit span test forward differed significantly, $t(19) = -2.57$ $p = .02$), in the second session ($M = 6.3$, $SD = 1.26$) compared to the first session ($M = 5.6$, $SD = .88$) of the study. The backward version of the Digit span test also differed, $t(19) = -2.46$ $p = .02$), between the two sessions ($M = 4.6$, $SD = 1.35$, $M = 4.05$, $SD = .95$, Time 2 and Time 1 respectively).

In addition, in order to control the possible effects of Age and Years of school education on the improvement on the neuropsychological tests, repeated measures ANOVA were conducted on each test, with Age and Education variables as covariates. The differences between sessions on the tests' scores did not change were the covariates were introduced, thus there was no effect of the age and the education on the difference in the performance on the second session compared to the first session of the study. Considering the accuracy on the Trail making tests A and B (i.e., the number of errors), the improvement at Time 2 was no long significant, $F(1,18) = 2.7$, $p = .12$, and the number of errors on the Trail Making Test B ,$F(1,18) = 2.7$, $p = .11$, between the two sessions of the study.

2.2.4 Discussion

The present study was conducted in two separate sessions (i.e., Time 1 and Time2) with the group of alcohol dependent participants. The AUDIT and C.A.G.E. questionnaires were use to determine the level of alcohol use and alcohol dependence, indicating that this group of participants had a harmful alcohol use and presented elements of alcohol dependence. The first session was conducted at the very beginning of the treatment and the second session after an average of 6.94 (*SD* = .99) months of the recovery program. The recovery program was based on the complete abstinence of the patients and on the support group sessions for alcohol related problems. The aim of the study was to determine a change in the neuropsychological functions that are most vulnerable to the alcohol dependence, after a fixed period of abstinence. The literature indicated that the functional components of the brain are reversible at least in part after few weeks of abstinence. But not all functions have the same recovery period (Oscar-Berman, & Marinković, 2007). The main hypothesis was that the change (i.e., improvement) of these functions (i.e., performance on the related tests) would be significantly different after a period of six months of recovery. The results confirmed the reversibility of the mental flexibility and visual and motor speed (i.e., Trail Making test B) and the working memory capacity (i.e., Digit span forward and backward). In particular, the performance on the Trail Making test part B seemed to improve between the two sessions (i.e., less time to complete the test B). As indicated by previous studies the visuo-motor and the mental flexibility (i.e., the ability to switch the task sets) capacity improved during the abstinence period, as indicated by the change in the performance on the Trail Making Test B. A second function that significantly changed between the two session of the study was the working memory capacity. Both, the Digit span forward and the Digit span backward improved within the abstinence period (i.e., increased digit sequence in forward and backward version of the test). The literature indicated that this mental function shows resistance to the recovery during the first months of the abstinence. The ability to maintain and manipulate information in the short-term memory improved within six months period for the present group of participants.

Moreover the number of errors on the Trail Making tests A and B decreased significantly between the two sessions. Never the less, when age was introduced as a covariate, the change in the errors on these two tasks between sessions was no longer

significant. This result could be related to the fact that the alcohol dependence is associated to the frontal lobe damage and the errors on the Trail Making Tests A and B are not sensitive to the frontal lobe lesions (Salthouse, 2010). No significant change emerged for the verbal fluency test. The tests that did not showed a performance change were the Verbal fluency tests (i.e., the Phonemic and the Semantic tests) and the Trail Making test part A. The absence of change in the performance on the Trail Making part A could be could be attributed to the fact that the visuo-motor speed assessed was not significantly impaired in the clinical sample, if we consider that the change was measured in the part B of the test which is more complex (i.e., visuo-motor speed and mental flexibility). Moreover, the verbal fluency assessed with the Phonemic and Semantic tests did not showed a change in the performance (i.e., improvement). It could be speculated that this function also was not significantly impaired in the present group of participants. A secondary speculation could reflect a general impairment of the verbal fluency that could not be reversed during a period of recovery program. Therefore, a limit of the present study resigns in the absence of a control group of healthy adults (equal for Age, Gender and Education) to compare the performance of the clinical group at the beginning and after six months.

In the present chapter the focus was on the neuropsychological functions that are impaired under the effect of alcohol in the dependent individuals. Thus, the harmful alcohol use is responsible for a reduction in the correct functioning of the mental processes that are associated to the frontal lobes. The effects of the harmful alcohol consumption presented in this chapter can be considered as relatively short-term and reversible alcohol effects. The importance of these neuropsychological impairments is high if the success of the recovery program is considered. In fact, it is important to consider the damage of the frontal lobe due to the alcohol abuse, in order to evaluate if effectiveness of the therapy information and their correct elaboration. In the next part of the present work the attention will be dedicated to the other implications of the alcohol consumption. In particular, the focus will be on the alcohol addiction that involves the more long lasting modifications in the brain and on the socio-cognitive underpinnings of these processes.

CHAPTER 3

SOCIO-COGNITIVE VARIABLES INVOLVED IN ALCOHOL USE AND ABUSE

3.1 The Incentive Sensitization Theory of Addiction model

The World Health Organization indicated the alcohol as the principal cause of death for 3,3 million people around the world during the 2012 (ISTAT, 2015). The National Institute of Statistics (i.e., ISTAT) stated that during the 2014, eight million two hundred and sixty five people in Italy had a risky alcohol consumption that could lead to health problems. Moreover, 15% of man and 6,2% of women consumed alcohol in a way that was considered excessive for their personal drinking habits. Together, this evidence claims for research aimed at understanding the processes that promote, sustain and maintain alcohol related and alcohol addiction problems. The Incentive Sensitization Theory of Addiction (i.e.,ISTA) provides an account for the psychological and neurological basis of alcohol addiction. According to this theory, the pleasure related to the alcohol consumption constitutes the first step of incentive motivations and activates mechanisms of associative learning and incentive salience. Repeated exposure to the drugs weakens the pleasurable effects of the drugs, and increases the sensitization of the brain system that is associated with incentive motivation and rewards, thus implementing the compulsive seeking of the drug.

A central feature of the ISTA is that changes in the brain, in particular in the mesocorticolimbic circuits leads to drug addiction. These brain areas account for the incentive motivational functions that attribute an incentive salience to drug-related stimuli (for a review, see Robinson, & Berridge, 2008). Thus, drugs in general, including alcohol, increase the dopamine neurotransmission in the mesotelencephalic area, which becomes more sensitized to drug-related stimuli. By a classical conditioning process, drug-related stimuli gain a conditioned incentive function (i.e., incentive salience), which is a specific type of motivation, referred to as ‘wanting’. The ‘wanting’ differs from other forms of desires based on declarative goals or explicit expectations.
In fact, the incentive salience stems from an enhanced focus on reward-related stimuli.
It is worth noticing that the reward property of the drug as well as the drug-related

stimuli is independent of any modification of the neural system implicated for the drug-liking, such as the drug hedonic effects. The drug-wanting and the drug-liking are dissociated processes, whit the liking being, at least in certain cases, an initial trigger of drug consumption, but tend to decrease with the development of the form of adaptation referred to as tolerance (Robinson, Robinson, & Berridge, 2013). The tolerance indicates a reduction in the hedonic effects of the drug that could increase the dosage of the consumed drug (Ahmed, & Koob, 2005). Moreover, the drug stimulation of the brain circuits can, at least in some cases, involve only the brain area responsible for wanting without stimulating those networks accountable for drug liking (i.e., wanting without liking). Hence, it may be the case that drugs become more wanted despite not being especially 'liked'. The dissociation between the 'wanting' and 'liking' has been recently demonstrated by a study (Pool, Brosch, Delplanque, & Sander, 2014), addressing how the rewards are used to reduce the negative effects of stress. The authors (Pool et al., 2014) demonstrated that participants in a stress-induced condition, compared to participants in the stress-free condition, were more prone to take instrumental action (i.e., mobilize efforts to squeeze a handgrip that releases a chocolate odor), when exposed to reward-associated cues. Importantly, the two experimental groups did not report rewards as being more pleasant. These results testify to the enhancement of cue-triggering wanting regardless of the hedonic characteristics of the rewards.

The incentive salience leads drug-related stimuli to become attractive (Fiels, Mogg & Bradley, 2005), attention grabbing (Sharma, Albery, & Cook, 2001), and trigger approaching-like motor actions (Cousijn, Goudriaan, & Wiers, 2011; Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011). In other words, repeated drug use likely shapes a series of cognitive biases in favor of drug-related cues. In the current research program, we intend to take a step further in understanding the way incentive salience orients cognitive process in general, and early attention process in particular. We reasoned that 'liking' can be operationalized as the automatic evaluative reactions towards the drug-related cues (e.g., Houben et al., 2009; Ostafin et al., 2008; Houwer et al., 2004), while the incentive salience can be measured as the self-relevance of the drug and the drug-related cues (Greck et al., 2007). We reasoned that the automatic self-relevance of the alcohol-related stimuli, more so than the automatic evaluation of these stimuli, would guide the attention towards the alcohol-cues over the non-alcohol cues. This hypothesis is tested across three studies using three different samples, namely the

alcohol addicted and abstinent group (AbG), the alcohol addicted and dependent group (i.e., DG), and the group of moderate drinkers (MD). These three groups of participants have been sensitized to alcohol albeit to a different extent. The DG and AbG are both addicted to alcohol, while the MD is not an alcohol-addicted group. The AbG and the MD are not in the condition of alcohol dependence. Testing our hypothesis across these three groups will provide us with boundary conditions of the association between the automatic self-relevance of the alcohol-related concepts and the attentional bias in favor of alcohol-cues over non-alcohol cues.

3.2 Implicit evaluation, arousal and self-relevance of alcohol related stimuli

Cognitive psychology distinguishes between explicit and implicit psychological processes. Implicit processes are typically automatic, they are non-intention driven, require low cognitive efforts and are, at least in part, save from control. By contrast, explicit processes are sensitive to contextual factors, such as self-presentation concerns or social desirability variables, mobilize a high amount of cognitive resources, and can be controlled to match overt intentions and goals (Nosek, 2007).While explicit processes are typically assessed by self-report measures, implicit processes are often assess via reaction time measures, such as the semantic sequential priming (Heuer, Rinck, & Becker, 2007), the approach avoidance task (Cameron, Brown-Iannuzzi, & Payne, 2012), and the Implicit Association Test (i.e., IAT; Greenwald, & Nosek, 2001).

In the current research program we rely on the IAT. This test is a computerized categorization task that assesses the strength of associations between two target categories and two attribute categories. Specifically, the evaluative IAT assesses the automatic evaluation between a class of categories and positive/negative attributes. Two target categories are typically used, that is words indicating alcoholic and non-alcoholic drinks, and two evaluative attributes, which are positive and negative words. Following the procedure described by Greenwald (Greenwald et al.; 1998), participants went on five blocks. In the first block, participants distinguish target categories by pressing, for instance, the left key for stimuli related to alcoholic and the right key for stimuli related to non-alcoholic drinks. In the second block participants classify attributes by pressing the left key for positive stimuli, while they use the right key for negative stimuli. In the

third block they categorize stimuli related to alcoholic and to positive stimuli by pressing the same response key, in this example the left key, and pressing the right key for exemplar stimuli related to non-alcoholic and negative stimuli. This third block is referred as the combined categorization Alcoholic-Positive. In the fourth block, participants go on the second block but with reversed response keys. In the fifth block, they categorize stimuli related to alcoholic and to negative by using the left key, and pressing the right key for stimuli related to non-alcoholic and to positive stimuli. This fifth block is labeled as the combined categorization of Alcoholic-Negative. The IAT score combines participants' performance (i.e., speed of categorization and accuracy, Greenwald et al., 2003) in the third and in the fifth block (see Greenwald, 2003, for similar procedure). Higher scores indicated a stronger association of Alcoholic-Positive over Alcoholic-Negative.

Empirical efforts in the domain of alcohol use and abuse have relied on the evaluative IAT to measure the automatic evaluation of alcohol. Specifically, research that has involved participants with alcohol addiction problems has reported, at least in this population, a stronger alcohol negative over positive association, thus suggesting a negative evaluation of the alcohol in the alcohol-dependence individuals (e.g., De Houwer et al. 2004, Wiers, 2002)as well as in the moderate drinkers (e.g., Houben, & Wiers, 2009).

Furthermore, additional research has relied on the IAT to assess the arousal-alcohol association. As the arousal-related effects of the alcohol can be considered as anticipated characteristics of the rewards, this automatic measure has been used as indexing the 'wanting' motivation. Heavy drinkers have been found to strongly associate the alcohol category to the arousal concepts over the sedation concepts (Thush, & Wiers, 2007, Houben, & Wiers, 2006). In the current set of study we put forward an operationalization of the 'wanting motivation', alternative to the automatic alcohol-arousal association, namely the self-relevance of the alcohol and alcohol related stimuli. We reasoned that the valuation system of stimuli comprised a coding process of the stimuli's immediate relevance, which is the reward value, and a coding of a long-term value for a given individual. The stimulus value represents a key characteristic of the reward, whereas the stimulus long-term value refers to the importance and the meaning of that stimulus for the self. From a neuroanatomical perspective, reward values involve activity in the nucleus accumbens (i.e., NACC), the ventral tegmental area (i.e., VTA) and the ventromedial prefrontal cortex (i.e., VMPFC). Similarly, the

stimuli's relatedness to the self involves a variety or brain area, including the NACC, the VTA, and the VMPFC. Hence, from the anatomical perspective, the reward values and the self-relevance of the stimuli likely shares similar brain networks. From an empirical perspective, Greck et al. (Greck et al., 2007) tested this hypothesis by presenting to a group of participants three decision-making tasks while collecting the data on the brain activity with an event-related MRI. The first task assessed the reward component, and it included a win and loses gambling condition. The second task aimed at measuring the self-relevance of the stimuli by categorizing the presented stimuli as highly or lowly relevant to the self. The third task was a control condition in which participants had to judge the stimuli orientation in the space. The MRI results confirmed that the brain areas activated during the reward and the self-relevance tasks were largely overlapping (NACC, VMPFC and VTA) at least in the early stage of the information processing. These results indicate that, at least in the early phase of stimuli elaboration, no difference occurs in terms of brain area involved in the processing of the reward value of the stimuli and in the processing of the self-relevance of the same stimuli.

Taking advantage of this theoretical and empirical evidence, we argue that as the reward is a key feature of the 'wanting', the self-relevance of the stimuli likely constitutes an additional long-term value of the 'wanting'. We then decided to measure the self- relevance of the alcohol and non-alcohol related stimuli in an implicit manner, via the IAT. Specifically, the self-relevance IAT includes the self/other as concept categories, and the alcoholic/non-alcoholic drinks as attribute categories.

3.3 Automatic alcohol evaluation and alcohol-self relevance in clinical and non-clinical samples

According to the ISTA, during the process of addiction, an increased and discontinuous drug (e.g., alcohol) self-administration sensitizes the brain circuit responsible for 'wanting'. As a case in point, Robinson and Berridge (Robinson, & Berridge, 2008) claim that process of sensitization leads to increased levels of wanting, that tends to become stronger with each consumption of the substance, and likely persists long after the interruption of the consumption (Robinson and Berridge, 1998). Therefore, the self-relevance of the drug, as a measure of 'wanting', should also become

stronger with the progression of the addiction. Moreover, prolonged period of abstinence is assumed to additionally amplified the wanting motivation, and by implication the self-relevance of the drug (Robinson et al., 1998).

Nevertheless, some other research indicates that constant self administration of the substance of abuse, in a condition of unlimited access to drugs (e.g., alcohol), could lead to a malfunction of the system, namely a desensitivization of neuronal mechanism that mediates the rewards, leading to a weaker 'wanting', and by implication of the self-relevance of the drug (for a review Spanagel, & Weiss, 1999).Given these two alternative claims, we put forward two different hypotheses for the dependent group of participants (i.e., DG). First, we hypothesize that this group would have a stronger self-alcohol over self-non alcohol association because they are alcohol addicted, as they have been sensitized to the substance (Hypothesis 1a). By contrast, the second hypothesis considers the fact that this group was at the very beginning of the treatment and still had an unlimited access to alcohol and could have drunk any quantity at any time; therefore the self-alcohol association could be less strong than self-non alcohol association in this group of participants (Hypothesis 1b).

As for the abstinent group (i.e.,AbG) we hypothesize a stronger self-alcohol over self-non alcohol association, given the fact that they are in abstinence from alcohol and has not consumed the substance for at least three months (Hypothesis 2). Finally, for the moderated drinkers (i.e., MD) that have no alcohol addiction problems, we hypothesize that the self-relevance of the alcohol and alcohol related stimuli should be low, and therefore they could show a lower self-alcohol over self-non-alcohol association (Hypothesis 3). Moreover, in the current set of studies, we also measure the automatic evaluation of the stimuli by the IAT, using alcoholic/non-alcoholic drinks as concept categories, and positive/negative words as attribute categories. The research conducted on the automatic evaluation of the alcohol related stimuli, namely, the association between the concept of alcohol and positive or negative attributes, has found a more negative (i.e., stronger alcohol-negative association) than a positive automatic association (Stacy, & Wiers, 2010, Houben, & Wiers 2007, De Houwer, Crombez, Koster, & De Beul, 2004). These results have been found with different groups of participants, such as the alcohol addicts under clinical treatment (DeHouwer, Crombez, Koster, De Beul, 2004), the heavy and light alcohol drinkers (Houben, Wiers, 2009, Wiers, Woerden, Smulders, & De Jong, 2002).Considering the studies previously

mentioned, we hypothesize that all three group of participants (i.e., DG, AbG and MD) would have a stronger negative automatic evaluation (i.e., alcohol-negative) over a positive evaluation of the alcohol (i.e., alcohol-positive).

Finally, and in line with the ISTA, which claims for an independence of the substance 'liking' and 'wanting', and given the evidence suggesting two separates neural correlates of the liking and wanting system (Robinson and Berridge, 2008), we explore whether the self-relevance IAT and the evaluative IAT would not be correlated in the AbG, DG and MD.

3.4 On the association between self-relevance and attentional bias

Self-relevance indicates an automatic association of non-evaluative attribute concepts to the concept of self (Greenwald et al. 2002).Research rooted in the social cognition tradition has demonstrated that the extent to which a stimulus is associated with the self heightens the sensitivity to the stimuli (Bargh, 1982), increases the efficiency and the speed of stimuli processing (Markus, 1977; Kupier, & Rogers, 1979). Moreover, individuals tune attention into elements that are self-relevant and tune out information that is not important to self-related goals (Rigutti, Fantoni, & Gerbino, 2015). In sum, stimuli sensitivity, stimuli encoding and stimuli-attention processes are enhanced when the stimuli are appraised as self-relevant. The core hypothesis of the current set of studies is that the self-relevance of the alcohol stimuli would moderate the attentional-bias toward alcohol stimuli (over non-alcohol stimuli). The attentional bias refers to a change in the cognitive functioning (i.e., attention), in the way that allows for a faster and more accurate process of relevant over irrelevant stimuli (Marissen et al, 2006, Luck et al., 1996). Thus, the more the stimuli is self-relevant, the more it is attention grabbing for the perceiver (Bargh, 1982). Attentional bias towards alcohol stimuli constitutes a key feature of the process of addiction as alcohol addicted individuals' attentionis highly likely to be captured by alcohol-related cues, suggesting the attention-grabbing proprieties of the alcohol-related cues, at least in this population. Different tools and methodologies have been used to study the attentional bias in alcohol users and abusers. For instance, a modified version of the stroop-task (Cox, Hogan, Kristian, & Race, 2002, Sharma, Albery, & Cook, 2002) and the visual dot probe task (Teunissen et al., 2012, Mogg, Zelter, & Bradley, 2003, Townshend, &

Duka, 2001)have been employed to assess the attentional bias towards alcohol stimuli.

In the current set of studies we rely on the visual probe task. In this task, participants are presented on a computer screen pairs of stimuli for a short duration (2000ms). Each stimulus pairs comprised a drug-related cue (e.g., a bottle of wine) and a matched control, drug-unrelated stimulus (e.g., a bottle of water). Immediately after stimulus offset, a small probe, such as a dot, appears either in the same spatial location of the drug-related cue or of drug-unrelated stimulus. Participants are requested to respond to the cue as fast as possible by pressing a key associated with the spatial position of the probe. Results indicated faster reaction times to probes that replaced the drug-related cue than the drug-unrelated stimulus, testifying to an attentional bias in favor of drugs. Several studies have reported this attentional bias towards tobacco (Ehrman et al. 2002), opiate-drugs (Luban et al., 2000) and alcohol (Fadardi & Cox, 2008). To our knowledge, no study has directly tested whether the automatic self-relevance of the alcohol and/or the automatic evaluation of the alcohol predict the attentional bias towards alcohol stimuli. As a matter of fact, research has assessed implicit attitudes (e.g., automatic alcohol-evaluation/arousal; the approach and avoidance motor-like responses to alcohol stimuli) as predictors either of self-report measures of intention to consume alcohol or of the actual drinking behavior (Houben, & Wiers, 2009, Ostafin, Marlatt, & Greenwald, 2008, Houben, & Wiers, 2006). Differently from these studies, we address whether the attentional bias towards alcohol stimuli would be present at higher levels of self-relevance, independently to the level of automatic evaluation. We reason that, as the reward is a key feature of the 'wanting', and the self-relevance of the stimuli operationalized the 'wanting', higher levels of automatic self-relevance should enhance the attention-grabbing of the alcohol-related stimuli. On the contrary, as the reward is not contingent on the 'liking', we suggest that the automatic evaluation of the stimuli would not predict the attentional bias, as the 'liking' of the stimuli is not involved in the process of addiction (Robbinson and Berridge, 2008), and the 'liking' does not constitute attentional grabbing features of the alcohol stimuli (Hobbs, Remington, & Glautier, 2005).

3.5 Study 1

3.5.1 Participants. Thirty-nine individuals (N = 14 males, N = 25 females; age M = 57.36, SD = 10.09), that had a clinical condition of alcohol addiction and were attending the alcohol addiction support groups at the Association for Treatment and Support for alcohol addicts (A.C.A.T., Pordenone, Italy), voluntary took part to the current study.

3.5.2 Procedure. Participants were administered two sets of tests. One set comprised explicit measures of alcohol use and disorder: the 10-item version of The Alcohol Use Disorder Identification Test (i.e. AUDIT, Babor, Higgins-Biddle, Saunders, & Monteiro, 2001) and the C.A.G.E. questionnaire (Ewing; 2004). The former measure allowed us to assess whether the participants' alcohol consumption can be considered as at risk for developing alcohol related problems. The C.A.G.E. questionnaire was used to detect elements of alcoholism thus indicating the risk for alcoholism.

The second set included the implicit measures. Specifically, participants were administered two different Implicit Association Tests (i.e., IAT; Greenwald et al.; 1998), namely the alcohol-evaluation IAT (i.e., evaluative-IAT) and the self-relevance IAT (i.e., self-IAT). The IAT is a computerized categorization test that assesses the strength of associations between two target categories and two attribute categories. In the evaluative-IAT, the two target categories were the words indicating ALCOHOLIC ("*Alcolico*" in Italian) and NON-ALCOHOLIC ("*Analcolico*" in Italian) drinks, and the two attribute categories were the POSITIVE ("*Positivo*" in Italian) and NEGATIVE ("*Negativo*" in Italian) words. Following the procedure outlined by Greenwald (Greenwald et al.; 1998), participants went on five blocks. In the first block, participants distinguish target categories by pressing the left key("D")for exemplar stimuli related to ALCOHOLIC and the right key ("K") for exemplar stimuli related to NON-ALCOHOLIC. The exemplar stimuli related to ALCOHOLIC were the following words: beer (*birra*), wine (*vino*), liquor (*liquore*), grappa (*grappa*), whisky (*whisky*). The exemplar stimuli related to NON-ALCOHOLIC drinks were the following words: water (*acqua*), juice (*spremuta*), lemonade (*limonata*), orangeade (*aranciata*), milk (*latte*). In the second block participants distinguished attribute categories by pressing the left key (D) for exemplar stimuli related to POSITIVE and the right key (K) for

exemplar stimuli related to NEGATIVE. The exemplar stimuli related to POSITIVE were the following words: paradise (*paradise*), happiness (*felicità*), love (*amore*), honesty (*onestà*), peace (*pace*). The exemplar stimuli related to NEGATIVE were the following words: earthquake (*terremoto*), disgust (*schifo*), murder (*omicidio*), hate (*odio*), anger (*rabbia*). In the third block they categorize target categories and attribute categories by pressing the left key (D) for exemplar stimuli related to ALCOHOLIC and to POSITIVE, and pressing the right key (K) for exemplar stimuli related to NON-ALCOHOLIC and to NEGATIVE words (i.e., combined categorization, abbreviated as Alcoholic-Positive). In the fourth block, participants repeated the second block but with reversed responses (i.e., they pressed the left key (D) for exemplar stimuli related to NEGATIVE and the right key (K) for exemplar stimuli related to POSITIVE words). In the fifth block, they categorized target categories and attribute categories by pressing the left key (D) for exemplar stimuli related to ALCOHOLIC and to NEGATIVE, and pressing the right key (K) for exemplar stimuli related to NON-ALCOHOLIC and to POSITIVE (i.e., combined categorization, abbreviated as Alcoholic-Negative). The IAT score is computed combing participants' performance (i.e., speed of categorization and accuracy) in the third and in the fifth block (see Greenwald, 2003, for similar procedure), thus higher scores indicated a stronger association of Alcohol-Positive over Alcohol-Negative.

In the self-IAT, the two target categories were the words SELF (*"Sé"* in Italian) and OTHER (*"Altro"* in Italian), and the two attribute categories were the words ALCOHOLIC and NON-ALCOHOLIC. The exemplar stimuli related to ALCOHOLIC and NON-ALCOHOLIC were the same as the exemplars used in the evaluative-IAT. As for the exemplar stimuli related to the SELF (*Sé*), words such as I (*io*), Me (*me*), My (*mio, mie, mia*) were used as stimuli. The words You (*tu*), They (*loro*), Your (*vostri*), Them (*essi*), You (*voi*) were used as exemplar stimuli related to OTHER (*Altro*). The experimental procedure of the self-IAT was exactly the same as the procedure used for the evaluative-IAT. Specifically, in the first block, participants distinguish target categories by pressing the left key ("D") for exemplar stimuli related to the SELF and the right key ("K") for exemplar stimuli related to OTHER. In the second block participants distinguished attribute categories by pressing the left key (D) for exemplar stimuli related to ALCOHOLIC and the right key (K) for exemplar stimuli related to NON-ALCOHOLIC words. In the third block they categorized target categories and

attribute categories by pressing the left key (D) for exemplar stimuli related to SELF and to the ALCOHOLIC, and pressing the right key (K) for exemplar stimuli related to OTHER and to NON-ALCOHOLIC (i.e., combined categorization, abbreviated as Alcoholic-Self). In the fifth block, they categorized target categories and attribute categories by pressing the left key (D) for exemplar stimuli related to the SELF and to NON-ALCOHOLIC, and pressing the right key (K) for exemplar stimuli related to OTHER and to ALCOHOLIC (i.e., combined categorization, abbreviated as Alcohol-Other). Importantly, and for each IAT, the order of presentation of the third and the fifth block (i.e., the target-attribute combinations that shared the response keys was counterbalanced across participants. In each IAT, the sequence of the stimuli presentation was randomly generated.

The evaluative-IAT provided us with an automatic measure of attitude towards the alcohol, whereas the self-IAT was designed to assess the automatic alcohol-self association, thus tapping the relevance of the alcohol for the self-concept.

When they accomplished these two IATs and filled out the explicit measures (implicit and explicit measures were counterbalanced across participants), participants were administrated the Visual Dot Probe Task. This task was aimed to assess participants' attentional bias toward alcohol related stimuli. In this task participants had to determine a position (i.e., left or right) of a target (i.e., a black dot) by pressing two response keys (i.e., S or L). Before the target appeared on a computer screen, the participants were presented with two words indicating an alcoholic and a non-alcoholic drink. The words related to alcoholic and non-alcoholic drinks were the same as in the IATs. Each trial started with a fixation point presented for 500 ms a black-framed rectangle (19 cm X 9.5 cm) appeared on the center of the screen (14.5"). The rectangle was vertically divided into two equal squares by a black line, so that one square (9.5 cm X 9.5 cm) was on the right of the screen and the other square (9.5 cm X 9.5 cm) was on the left of the screen. Two randomly selected words, one pertaining to the alcoholic and one referring to the non-alcoholic drinks, appeared on the screen. Specifically, one of the two selected words was shown in the middle of one square, while the other word was shown in the middle of the other square. Words stayed on the screen for 2000 ms and then were deleted from the squares. Then the target appeared on the screen at the location of either one of the two words. Participants went on 100 trials. In fifty trials the dot appeared in the same location as the alcoholic words (i.e., relevant trials), while in

the reaming fifty trails the dot was shown at the same location as the non-alcoholic drink words (i.e., irrelevant trials). Trials were presented in random order. Moreover, the location of the alcohol and non-alcoholic drink words, namely on the left or on the right square, were counterbalanced across participants. At the end of the study, participants were thanked and debriefed.

3.5.3 Results

Audit. On the Alcohol Use Disorder Identification Test participants scored (M = 4.85, SD = 5.35) under the cut off score for harmful alcohol use (i.e., cut off score of 8 for man and female).This result attested that participants did not engage in risky alcohol consumption (Figure 3.1.). A dichotomous AUDIT risk variable was created, attributing 0 to all participants that scored under 8 (i.e., no risky drinking behavior, 87.2 % of the sample) and 1 to all participants that scored 8 or more (i.e., risky alcohol consumption, 12.8 % of the sample).

C.A.G.E. Participants scored on the CAGE questionnaire above the cut off score of 2 (M = 2.79, SD = 1.1), indicating the effects of alcoholism, which is in line with the fact that all participants had experienced alcohol abuse (Figure 3.1.). As the AUDIT scores, a dichotomous CAGE risk variable was created, attributing 0 to all participants that scored under 2 (i.e., no effects of the alcoholism, 12.8 % of the sample) and 1 to all participants that scored 2 or more (i.e., effects of alcoholism, 87.2 % of the sample).

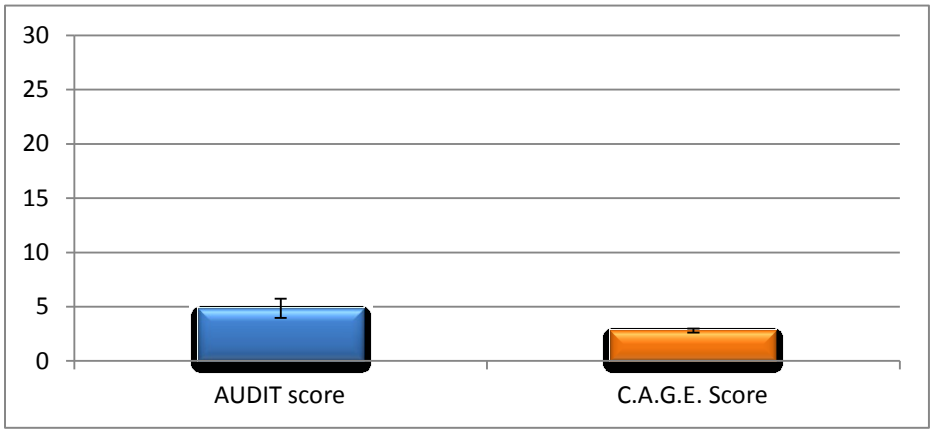

Figure3.1. Alcohol Use Identification test (i.e., AUDIT) and C.A.G.E. questionnaire (On the ordinate Mean score and Standard Error for both tests) in Study 1.

IAT. The Implicit Association Test's scores, for both the evaluative and self-IAT, were calculated according to the D600 scoring algorithm, proposed by Greenwald and colleagues (2003), so that higher scores indicated faster responses (i.e., stronger association) for the congruent combination (i.e., ALCOHOLIC-Positive/NON-ALCOHOLIC-Negative; ALCOHOLIC-Self/NON-ALCOHOLIC-Other) than for the incongruent combination (i.e., ALCOHOLIC-Negative / NON-ALCOHOLIC-Positive; ALCOHOLIC-Other/ NON-ALCOHOLIC-Self).

Evaluative-IAT. Participants' score at the evaluative-IAT was analyzed by means of a one-sample *t*-test (test value = 0). Results indicated that participants displayed an evaluative-IAT score (M = .92, SD =.53) that significantly differed from zero $t(38) = 10.86$, $p < .001$. Participants displayed a stronger ALCOHOLIC-POSITIVE over ALCOHOLIC-NEGATIVE associations (Figure 3.2.).

Self-IAT. Participants' score at the self-IAT was analyzed by means of a one-sample *t*-test (test value = 0). Results showed that participants displayed a Self-IAT score (M = .37, SD = .60) that significantly differed from zero, $t(38) = 3.82$, $p < .001$, indicating a stronger ALCOHOLIC-SELF over ALCOHOLIC-OTHER associations (Figure 3.2.).

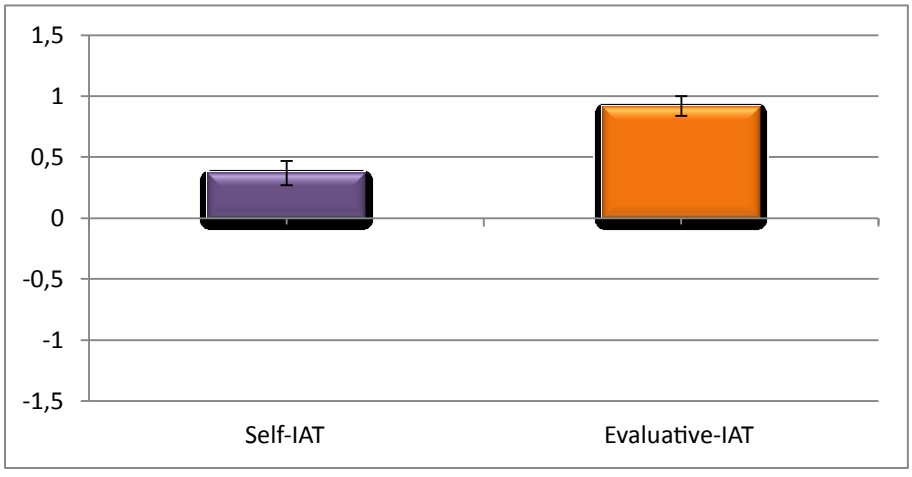

Figure 3.2. Self-relevance and Evaluation IAT-score of the alcoholic over non alcoholic stimuli (On the ordinate The Implicit Association Test score calculated with D600 scoring algorithm) in Study 1.

Correlation analysis. The two explicit measures, AUDIT and C.A.G.E. were significantly correlated, $r = .43$, $p = .006$, indicating that the more the participants had a risky alcohol behavior the more the effects of the alcoholism were displayed. The evaluative IAT and the Self IAT were not significantly correlated, $r = .26$, $p = .12$. The explicit and implicit measures were not significantly associated, testifying to the independence of these sets of measures, $r < .26$, $p > .12$.

Visual Dot Probe Task. The score on the Visual Dot Probe Task was calculated by subtracting the mean reaction times of the incongruent trials (i.e., the target appeared on the location of the NON ALCOHOL words to the mean reaction times of the congruent trials (i.e., the target appeared on the location of the ALCOHOL words. Negative scores indicated faster responses when the target (i.e., the black dot) appeared on the location of the ALCOHOL than on the location of the NON-ALCOHOL (we herewith refer to the negative score as the alcohol attentional shift), while positive scores indicated faster responses when the target appeared on the location of the NON-ALCOHOL words than in the location of the ALCOHOL (we herewith refer to the negative score as the non-alcohol attentional shift).Overall, the probe score ($M = 2.08$; $SD = 40.42$) did not differ from zero, $t(38) = .32$, p = .75 ($M = 692.21$, $SD = 194.88$, $M = 690.14$, $SD = 189.72$, for the ALCOHOL and NON-ALCOHOLIC word, respectively), indicating that participants took the same amount of time to detect the target when presented at the location of an alcohol or a soft-drink word. Said otherwise, neither the alcohol nor the non-alcohol attetnional shift occurred in the sample.

Testing the predictors of the attentional shift. The probe score was regressed on the standardized self-IAT, the standardized evaluative-IAT score, and the dichotomous variables AUDIT risk and CAGE risk. Results indicated that the Self-IAT was significantly associated with the attentional bias, $\beta = -.42$, $t(34) = -2.6$, $p = .01$, suggesting that a strong automatic association between the ALCOHOLIC and the SELF predicted the salience of the alcohol related stimuli. Specifically, the stronger the ALCOHOLIC/SELF association, the faster was the participants' identification of the dot when the target appeared on the location of the ALCOHOL word than of the NON-ALCOHOL word. The IAT evaluation was not significantly associated with the attentional shift, $\beta = .26$, $t\ (34) = 1.59$, $p = .12$. Moreover, neither the AUDIT risk, $\beta = -.09$, $t\ (34) = -.54$, $p = .6$, nor of the C.A.G.E., risk $\beta = .003$, $t\ (34) = -.02$, $p = .99$, were significantly associated with the attentional shift.

3.5.4 Discussion

This study was run on a sample of abstinent, albeit ex-alcohol abusers (i.e., AbG). Contrary to evidence reported in the literature, participants showed a positive automatic evaluation of the alcohol. Moreover, AbG significantly associated the alcohol with the self-concept. Although no attention bias in favor of alcohol over non-alcohol items was found on the overall sample, taking into account individual differences in terms of automatic attitudes helped us to gain a more fine-grained analysis of the mechanisms that biased participants' attention towards alcohol items. Indeed, the extent to which individuals implicitly associated their self-concept with alcoholic attributes, namely the degree to which they automatically considered the alcohol a self-relevant stimulus, predicted the time participants took to detect alcohol-related stimuli. Specifically, the stronger the strength of self-alcoholic association, the faster was the participants' identification of the dot stimuli when they appeared on the location of the alcohol than on the location of the non-alcohol items. Put it simply, the more the alcohol was associated to the self, the faster was the orientation of the attention towards alcohol stimuli. The evaluative IAT was not predictive of the attention bias, suggesting that it was not the attributed valence of the alcohol stimuli that drove participants' attention towards the stimuli in question. Importantly, the evaluative IAT and the self-relevance IAT were not correlated, indicating the independence of these two processes for the addicted individuals. Finally, no difference occurred in terms of attention bias as a function of the AUDIT as well as of the C.A.G.E. risk, suggesting that, at least in this sample, early cognitive processes, such as attention orientation towards alcohol stimuli, were not captured by these diagnostic devices. Finally, and in line with our hypothesis, the automatic evaluation of the alcohol stimuli and the self-relevance of these stimuli were not correlated, testifying to the independence of the 'liking' and 'wanting' in the process of addiction.

In study 2 we sought to replicate these findings. Specifically, we aimed to verify whether the attention bias towards alcohol over non-alcoholic items was selectively predicted by the automatic alcohol-self association, but not by the automatic alcohol evaluation. Moreover, and to bolster the external validity of results of the Study 1, in Study 2 we relied on a sample of patients that recently decided to quit alcohol abusing and were hosted in a clinical service in an abstinent regime (DG).

3.6 Study 2

3.6.1 Participants. Forty-nine individuals (N = 27 males, N = 22 females; age *M* = 51.02, *SD* = 11.57) voluntary took part to the current study. Participants had a clinical condition of alcohol abuse and were at the beginning of their recovery program at the Department for treatment of legal drugs' abuse (Dipartimento per il trattamento delle dipnedenze legali, Azienda per I Servizi Sanitari n. 1, Trieste, Italy).

3.6.2 Procedure. As in Study 1, participants were administered two sets of tests. One set comprised explicit measures of alcohol use and disorder: The Alcohol Use Disorder Identification Test (i.e. AUDIT, Babor, Higgins-Biddle, Saunders, & Monteiro, 2001) and the C.A.G.E.in the masked form (Guerrini, Gentili, & Guazzelli, 2006, Ewing; 2004,). In the second set of tests, participants were provided with the two IATs as in the Study 1. The procedure and the experimental material of the current study were exactly the same as in Study 1.

Participants were then administrated the Visual Dot Probe Task aimed to assess the attentional bias toward alcohol related stimuli. In this task participants had to determine a position (left or right) of a target (a black dot) with two response keys (S or L). Before the target appeared on a computer screen, the participants were presented with two images indicating an alcohol and a non-alcohol drink. The images represented common brands of alcoholic and non-alcoholic drinks that were the same drinks represented with words in the two IATs.

Each trial started with a fixation point presented for 500 ms. A black-framed rectangle (19 cm X 9.5 cm) appeared on the center of the screen (14.5"). As in Study 1, the rectangle was vertically divided into two equal squares by a black line, so that one square (9.5 cm X 9.5 cm) was on the right of the screen and the other square (9.5 cm X 9.5 cm) was on the left of the screen. Differently form Study 1, in the current study participants saw pictures of alcohol and non-alcohol beverages. Specifically, two randomly selected images, one pertaining to the alcohol and one referring to the non-alcohol drinks, appeared on the screen. One of the two selected images was shown in the middle of one square, while the other image was shown in the middle of the second square. Images stayed on the screen for 2000 ms. Then, the target appeared on the screen at the location of either one of the two images. Participants went on 100 trials. In fifty trials the dot appeared in the same location as the image of the alcohol drink (i.e.,

relevant trials), while in the reaming fifty trails the dot was shown in the same location as the image of the non-alcoholic drink (i.e., irrelevant trials). Trials were presented in random order. Moreover, the location of the alcohol and non-alcohol drink images, namely on the left or on the right square, were counterbalanced across participants.

At the end of the study, participants were thanked and debriefed.

3.6.3 Results

Audit. Participants reported (*M* = 24.96; *SD* = 7.32) high level of alcohol problems (cut off score of 20), indicating that participants probably had developed alcohol addiction (Figure 3.3.).

C.A.GE.. Participants score on the C.A.G.E. questionnaire (M = 2.87, SD = .98, cut off score of 2 or higher for detection of alcoholism) suggested, a clinically significant effect of alcoholism (Figure 3.3.).

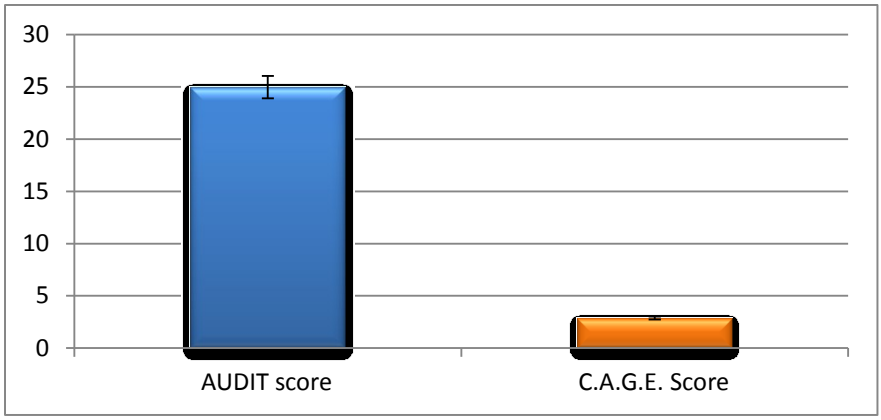

Figure 3.3. Alcohol Use Identification test (i.e., AUDIT) and C.A.G.E. questionnaire (On the ordinate Mean score and Standard Error for both tests) in Study 2.

IAT. The Implicit Association Test's scores were calculated as previously indicated in Study 1.

Evaluative-IAT: Participants' score at the evaluative-IAT was analyzed by means of a one-sample *t*-test (test value = 0). Results indicated that participants showed an evaluative-IAT score (*M* = -.79, *SD* = .63) that significantly differed from zero, *t*(47) = -8.70, p < .001, indicating a stronger ALCOHOLIC-NEGATIVE over

ALCOHOLIC-POSITIVE associations (Figure 3.4.).

Self-IAT. A one-sample *t*-test (test value = 0) was performed on participants' score at the self-IAT. Results indicated that participants showed a Self-IAT score (M = -.36, SD = .51) that significantly differed from zero, t (47) = - 4.84, p < .001, attesting a stronger ALCOHOLIC-OTHER over ALCOHOLIC-SELF associations (Figure 3.4.).

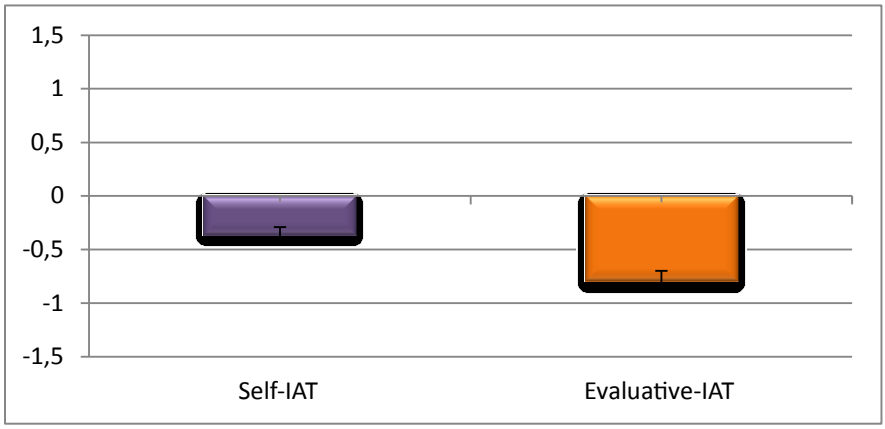

Figure 3.4. Self-relevance and Evaluation of the alcoholic over non alcoholic stimuli (On the ordinate The Implicit Association Test score calculated with D600 scoring algorithm) in Study 2.

Correlation analysis. The AUDIT and C.A.G.E. were significantly correlated, r = .38, p = .009, indicating that the more the participants indicated a risky alcohol behavior, the more they displayed elements of alcoholism. The two implicit measures, the evaluative IAT and the Self IAT, were not significantly correlated, r = .07, p = .63. The explicit and implicit measures were also not significantly associated, r < .07, p > .29 indicating the independence of these two sets of measures.

Visual Dot Probe Task. The score on the Visual Dot Probe Task was calculated in the same way as in Study 1, so that a negative score indicated faster responses when the target appeared on the location of the ALCOHOL image, while a positive score indicated faster responses when the target appeared on the location of the NON-ALCOHOL image. The probe score (M = 48.68, SD = 164.83) significantly differed from zero, t(47) = 2.05, p = .05. This result indicated that participants took less time to shift their attention when the target was presented at the same location of the non-alcohol drink's image (M = 650.47, SD = 233.14) than when the target was presented at

the same location as the alcohol drink's image (M = 699.15, SD = 333.09). In other words, participants showed anon-alcohol attention shift.

Testing the predictors of the attention shift. As in Study1, the probe score was regressed on the standardized evaluative-IAT score and the standardized self-IAT. Since all the participants in present study were recovering from alcohol addiction, all reported high alcohol related problems and risky behavior, therefore the variable Audit risk and Cage risk were not enter in the current regression model. Results indicated that the Self-IAT is negatively associated with the attentional bias, β = -.28, t (43) = -1.91, p = .06, albeit the significant level fell short of significance. This result indicated that the stronger the automatic association between the SELF and ALCOHOL, the faster was the identification of the target (i.e., the dot) when it was presented at the same location of the alcohol image than to the non-alcohol image. The IAT evaluation was not significantly associated with the attentional bias, β = .12, t (43) = .85, p = .4.

3.6.4 Discussion

The present study was carried on the group of alcohol dependent individuals (i.e., DG) at the beginning of the clinical treatment. Results on the Self-relevance IAT indicated a stronger association of self-non alcohol over self-alcohol, suggesting a negative automatic association between the self-relevance and the alcohol. As previously indicated, two hypothesis were made for the self relevance of the alcohol (i.e., 'wanting').The negative automatic association is in line with the second hypothesis that unlimited access and abuse of the alcohol could lead to a temporary reduction of the 'wanting', therefore to the reduction of the self-relevance of the alcohol (i.e., negative automatic association). On the contrary, the hypothesis stating that the 'wanting' should be stronger in the alcohol addicted individuals, was not confirmed by our data. As for the automatic evaluation of the alcohol, results indicated a negative association (i.e., stronger association of the alcohol concepts with negative attributes than of alcohol and positive attributes), which is in line with the hypothesis of the negative evaluation of the concept of alcohol for this group of participants. As for the Visual Probe Task, results indicated an attentional bias: participants were faster when the target appeared on the location of the non-alcohol drinks compared to alcohol drinks.

However, in line with our expectation, the degree to which individuals implicitly associated their self-concept to alcohol attributes, namely the automatic self-relevance of the alcohol stimuli, predicted the time participants took to detect alcohol-related stimuli, although this association fell short of statistical significance. Indeed, the stronger the self-alcohol association, the faster was the participants' identification of the dot stimuli when they appeared on the location of the alcohol than on the location of the non alcohol items. The evaluative IAT was not associated with the attentional bias, indicating that the evaluation of the alcohol stimuli was not a crucial factor in orienting participants' attention towards the stimuli in question.

As in the case of the abstinent group in Study 1, the automatic self relevance and the automatic evaluation of the alcohol did not correlate, confirming the independence of the process of 'wanting' and ' liking' for the dependent group of participants (i.e., DG).

In the third study, we intend to replicate results of Study 1-2 in a group of moderate drinkers (MD).

3.7 Study 3

3.7.1 Participants: Sixty-six university students (N = 12 males and N = 54 females, age M = 21.95, SD = 2.59) that had no clinical history of alcohol abuse took part in the present study in exchange for course credits.

3.7.2 Procedure: As in the previous two studies, all participants completed two sets of tests. They were administrated a set of explicit measures that included The Alcohol Use Disorder Identification Test (i.e., AUDIT, Babor, Higgins-Biddle, Saunders, & Monteiro, 2001) and a masked form of the C.A.G.E. questionnaire (Guerrini, Gentili, & Guazzelli, 2006, Ewing; 2004). In the second set of tests participants completed two IATs (i.e., the Evaluative-IAT and the Self-IAT) as in the previous two studies.

After completing the explicit and the implicit measures, all participants were administrated the Visual Dot Probe Task to assess the attentional bias toward alcohol related stimuli. The stimuli and the procedure of this task were the same as in Study 1,

using alcohol and soft drinks' related words as stimuli. At the end of the study, participants were thanked and debriefed.

As in Study 1, an AUDIT risk and C.A.G.E. risk scores were calculated, attributing 1 to all participants that were over the cut off point on these measures and attributing 0 to all participants that were under the cut off point on the same measures. In the present study we planned to test a group of moderated drinkers that have no alcohol related problems. Thus, participants that were at risk on both explicit measures (i.e., AUDIT risk = 1 and C.A.G.E. risk = 1) were excluded from the analyses ($N = 4$).

3.7.3 Results

Audit. On the Alcohol Use Disorder Identification Test participants obtained a mean score of 3.47 ($SD = 1.76$), which was under a cut off score of 8 for hazardous alcohol use (Figure 3.5.). As in Study 1, an Audit risk variable was created attributing 0 to all participants that scored under 8 (i.e., no risky drinking behavior, 98.4% of the sample) and 1 to scores equal or above 8 (risky alcohol behavior,1.6% of the sample).

C.A.G.E.. Only the responses on the CAGE items were considered in the present analysis. On average, participants reported a score on the CAGE ($M = .29$, $SD = .66$) that was under the cutoff point (i.e., score equal or higher than 2) indicating that the sample did not present effects of alcoholism (Figure 3.5.). A CAGE risk variable was created assigning 0 to all participants that scored under 2 (i.e., no effects of alcoholism91.9% of the sample) and 1 to all scores equal or above 2 (i.e., effect of alcoholism, 8.1% of the sample)

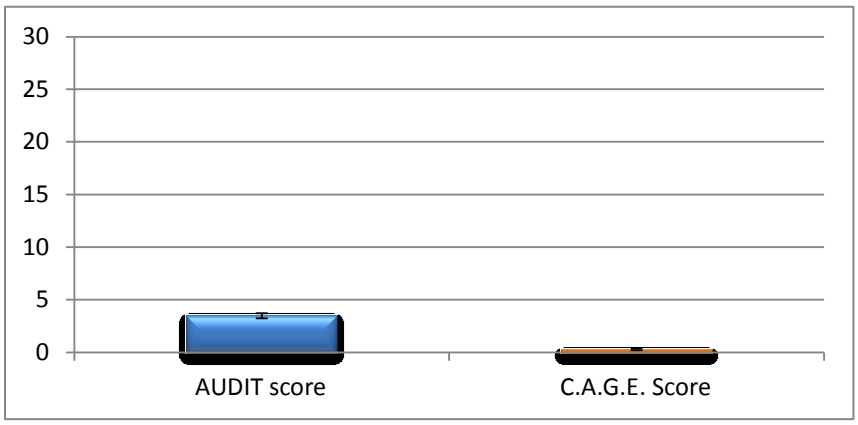

Figure 3.5. Alcohol Use Identification test (i.e., AUDIT) and C.A.G.E. questionnaire (On the ordinate Mean score and Standard Error for both tests) in Study 3.

Evaluative IAT. The evaluative-IAT score was analyzed by means of the one sample t-test (test value = 0). The results indicated a negative evaluative-IAT score (M = -1.09, SD = .55) that significantly differed from zero $t(61) = -15.6$, $p < .001$,showing a stronger alcohol-negative than alcohol-positive association (Figure 3.6.).

Self-IAT. The self-IAT score was analyzed by means of the one sample t-test (test value = 0). Participants showed a negative self-IAT score (M = -.33, SD = .62) that significantly differed from zero, $t(61) = -4.17$, $p < .001$,suggesting a stronger alcohol-other over alcohol- self association (Figure 3.6.).

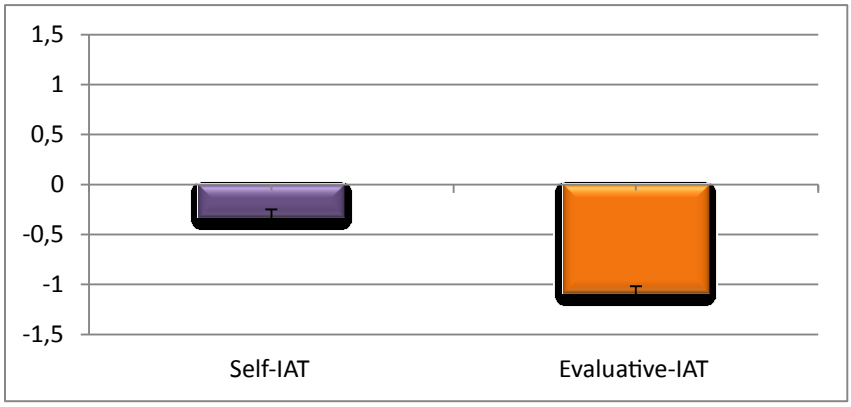

Figure 3.6. Self-relevance and Evaluation of the alcoholic over non alcoholic stimuli in Study 3.(On the ordinate The Implicit Association Test score calculated with D600 scoring algorithm)

Correlation analysis. The AUDIT and the C.A.G.E. correlated significantly, r = .36, p = .004, indicating that the more participants engage in a risky alcohol consumption, the more they show elements of alcoholism. The Self-IAT and the Evaluative-IAT significantly correlated, r = .26, p = .04, indicating that stronger the Self-Alcoholic association, the stronger is the Alcoholic-Positive evaluation, and vice versa. Moreover, the Self-IAT correlated significantly with the C.A.G.E. questionnaire, r = .33, p = .009 indicating that the more participants associated the Self with the alcoholic over non-alcoholic, the more they indicated elements of alcoholism on the questionnaire.

Visual Dot Probe Task: The score on the present task was obtained with the same procedure showed in Study 1. Negative scores indicated faster responses when the dot appeared on the same location as the word indicating an ALCOHOL drink, while

positive scores indicated faster responses when the dot shared the location of the word indicating a NON ALCOHOL drink. The probe score (M = -.97, SD = 13.74) did not differed significantly from 0, t (61) = -.55, p = .58 (M = 423.23, SD = 48.4, M = 424.19, SD = 48.37, for the ALCOHOL and NON-ALCOHOL words, respectively) indicating that participants took the same time to detect the dot when appeared on the location of the ALCOHOL and NON ALCOHOL word. Therefore no attentional shift occurred for the ALCOHOL or NON ALCOHOL related words.

Testing the predictors of the attentional shift. The Probe score was regressed on the standardized self and evaluative-IAT. The AUDIT risk and C.A.G.E. risk were not considered in the regression model as they were used to identify and exclude participants that were at risk for alcohol related problems. The self-IAT was negatively associated with the attention bias, β = -.24, t (59) = -1.82, p = .07, although the relation between the predictor and the dependent variable fell short of significance. This result indicated that the stronger was the association between the Self and the ALCOHOLIC drinks, the faster was the tendency to detect the dot when presented at the same location of the ALCOHOL word compared to a NON ALCOHOL word. The evaluative IAT did not predict the attentional bias, β = .07, t (59) = .53, p = .6. These results indicated that the Self relevance of the alcohol is a predictor of the attention towards alcohol over non-alcohol related stimuli for this group of participants.

3.6.4 Discussion

The present study involved a group of participants that were moderated drinkers (i.e., MD) and had no alcohol related problems in the past or present. As hypothesized, this group of moderated drinkers, with no alcohol addiction problems, has a stronger Self-non alcohol over Self-alcohol association, because the sensitization, therefore the 'wanting', has not occurred. As for the automatic evaluation, the hypothesis stated that the group of moderated drinkers should have a stronger Alcohol-negative over Alcohol-positive association, as the groups in Study 1 and 2. Thus, the results confirmed this hypothesis, indicating a stronger automatic Alcohol-negative over Alcohol-positive association. No significant effect was found for the attention bias toward the alcohol related stimuli. Said otherwise, there was no difference in the time participants took to detect the dot on the location of the alcohol compared to non alcohol items. Further

analyses on the association of the automatic Self-relevance of the alcohol and the attention towards the alcohol related stimuli indicated a negative association between these two variables, which fell short of significance. Therefore, a stronger Self-alcohol over Self-non alcohol association tends to predict a faster detection of the target on the location of the alcohol compared to non-alcohol words. The automatic evaluation of the alcohol, on the other hand, is not associated with the attentional bias. These results are in line with the claims that the Self-relevance of the alcohol has an important role even for the non addicted individuals. The automatic self-relevance and the automatic evaluation were correlated, contrary to Study 1 and 2, indicating that these two processes could be connected in a sample that has no alcohol use or addiction problems. For this group of moderated drinkers, the diagnostic measure (i.e., C.A.G.E) correlated with the implicit automatic measure (i.e., Self-IAT). This association indicates that, at least for this group of moderated drinkers, the less the alcohol is considered as Self-relevant, the less they tend to indicate elements attributed to the alcoholism.

3.7 Meta-analyses of results of Study 1-3

In Study 1-3 participants' score on the self-IAT was negatively associated with the probe score, and this effect was significant in Study 1 while in Study 2 and 3 it fell short of significance. In study 1-3, participants' score on the evaluative IAT was unrelated to the probe score. Following the procedure outlined by Brambilla, Riva &Vaes (2015), we meta-analytically combined the results from the effect sizes reported in Study 1-3. The meta-analyses showed that the weight-combined Z-score for the self-IAT was statistically significant ($Z = 2.695$, $p = .05$), whereas that for the valence-IAT was not, ($Z = 1.52$, $p = .30$). Furthermore the effect size for the self-IAT ($d = .46$, $\eta^2 = .05$) was small-to-intermediate (Cohen, 1988) and within the zone of desired effects (Hattie 2008). By contrast effect size for the valence-IAT ($d = .26$, $\eta^2 = .02$) was small (Cohen, 1988) and within the zone of teacher effect (Hattie 2008).

3.8 General discussion

The Incentive Sensitization Theory of Addiction (i.e., ISTA) designates the drug 'wanting' as the key feature of the process of addiction. On the other hand, the hedonic aspect of the drug or the 'liking' plays a role in the initial experience of drug consumption but not in the process of addiction. Moreover, the drug 'wanting' is responsible for attributing the incentive salience to the drug-related stimuli that become attention grabbing for the addicted individuals. These are the elements of the general model, propose by the ISTA, that refers to all types of drugs like opiates, marijuana, tobacco and ethanol (i.e., alcohol). In the presented work we tested this model within the context of alcohol addiction. The aim was to analyze whether the attention toward the alcohol related stimuli were guided either by the 'wanting' or the 'liking'. Both processes, namely the wanting and the liking, were assessed by implicit rather than explicit measures, thus circumventing participants' intentional control over their reactions, and capturing more spontaneous responses. The new feature of these set of studies is the way we operationalized the alcohol 'wanting'. Indeed, previous research has mainly referred to the 'wanting' as an arousal-correlated aspect of the alcohol. By contrast, we here suggested that the automatic association between one's self-concept and the alcohol representation might capture the 'wanting' aspect of the alcohol. Our claims were rooted in recent evidence attesting that processing the same set of stimuli either in terms of reward or in terms of relevance recruited very similar brain network, thus indicating that the self-relevance of a given stimulus overlaps, at least in part, the reward value of that stimulus. Based on this insight, across three studies, we measure participants' automatic self-alcohol association, as indexing the reward value of the alcohol, and participants' automatic evaluation of the alcohol, as operationalization of the alcohol liking. The key aim of these studies concerned the analyses of the potential predictors of participants' attentional shift towards alcohol stimuli, which was measured by using a well established paradigm, namely the visual dot probe task (Teuissen et al., 2012,Field, Mogg, Zelter, & Bradley, 2003, Townshend , & Duka, 2001). We anticipated that the self-relevance of the alcohol, and not the evaluation of the alcohol, would predict participants' attention shift.

We tested this hypothesis, with three different groups of participants. The main difference between these three groups consisted in their alcohol consumption habits. The first two groups (i.e., AbG and DG) were both involved in the process of alcohol

addiction, but were located at different steps of that process, whereas the third group (i.e., MD) was unrelated to the process of alcohol addiction. The abstinent group (i.e., AbG) went through the phase of alcohol dependence and, at the time, was not consuming alcohol. On the other hand, the second group of dependent participants (i.e., DG) was at the very beginning of the clinical treatment for alcohol addiction during their dependence phase. The third group (i.e., MD) consisted of participants that were not alcohol addicts but consumed alcohol in a moderated way, at least according to the screening tests that were used.

The hypothesis regarding the self-relevance of the alcohol as the predictor of the attentional shift was confirmed for all three groups of participants, although only for the AbG this association was significant, as for the DG and the MD fell short of significance. Moreover, the 'liking' (i.e., evaluation of the alcohol) was not predictive of the attention towards the alcohol related stimuli in all groups of participants. The importance of the self-relevance of the alcohol in orienting the attention towards the alcohol-related stimuli was confirmed by the meta-analyses conducted on the results from all three studies. Indeed, the effect size of the self-relevance of the alcohol in predicting the attention towards the alcohol related stimuli was small-to-intermediate, while the association between alcohol evaluation and attentional bias was small. As suggested by the ISTA, the 'wanting', but not the 'liking', is the central factor for the process of alcohol addiction and plays an important role in alcohol consumption, even if it is not pathological (e.g., MD).

We hypothesized that the self-relevance of the alcohol and the automatic evaluation of the related stimuli should be dissociable processes, as testified by evidence claiming for a marginal association between the 'wanting' and the 'liking' systems, and by research reporting a dissociation between these two systems, at least in the early phase of drug addiction. Our results indicated that the Self IAT and the evaluative IAT were not correlated in the AbG and in the DG groups, but were moderately correlated for the MD group. As for the alcohol addicted groups (i.e., AbG and DG) the results confirmed the independence of the two processes. The results for the MD group might attest that in a condition of moderated alcohol consumption both systems, those mediating the pleasurable effect (i.e., drug liking) and those mediating the rewarding effect (i.e., drug wanting), are stimulated by the alcohol consumption. As mentioned by the Incentive Sensitization Theory of Addiction (i.e., ISTA),in the initial phase of drug (e.g., alcohol)

consumption, the hedonic effects of the drug (i.e., "liking") can be accountable for the increased motivation to repeat the consumption experience. Meanwhile, the stimulation of the reward circuit begins with first drug consumptions (Robinson, & Berridge, 2008). Thus, the correlation between the alcohol "liking" and the alcohol "wanting" could be a result of the simultaneous stimulation of these two processes during the moderated alcohol consumption.

Our study allows for clinical consideration, comparing the three groups of participants. Indeed, results showed different levels of the self-relevance of the alcohol. The AbG participants showed a stronger self-alcoholic over self-non alcoholic association, while the DG and the MD displayed a stronger self-non alcoholic over self-alcoholic association. In line with our hypothesis, the high levels of alcohol-self relevance emerged for the abstinent group (i.e., AbG).As for the dependent group, the self-relevance of the alcohol was lower, due to the unlimited access and self-administration of the alcohol (hypothesis 1b.). The moderated drinkers (i.e., MD) showed also low level of alcohol-self relevance in line with the fact that they were not alcohol-addicted individuals.

As for the alcohol 'liking' or the evaluation of the alcohol, the AbG presented a stronger positive evaluation of the alcohol (i.e., stronger alcoholic-positive over alcoholic-negative association) and the DG and the MD presented a stronger negative evaluation (i.e., stronger alcoholic-negative over alcoholic-positive association). In this case, the hypothesis was confirmed for the DG and MD, but not for the AbG. Research conducted on the evaluation of alcohol (i.e., positive and negative associations regarding the alcohol) with heavy and moderated drinkers showed mostly a stronger alcohol negative over alcohol positive associations (De Houwer et al., 2004, Wiers, 2005). According to these researchers the negative association could be addressed to the negative alcohol related experiences (e.g., alcohol related problems). There is no research on the valence of the alcohol in an abstinent group that has no alcohol consumption experience for a period of time (i.e., abstinence). In this case a lack of negative alcohol related experiences could have led to a more positive over negative evaluation of the alcohol. However, more evidence is requested to corroborate this conjecture.

Research conducted on the drug addiction in general and on the alcohol

addiction in particular, mostly tests their models with heavy or moderated drinkers. In the present work we tested our model on three different groups with different alcohol related experiences. A limitation of these studies could be represented by the lack of a repeated testing of these groups, given the fact that the incentive sensitization is a process that manifests itself across time-span. As claimed by the Incentive Sensitization Theory of Addiction (i.e., ISTA) the drug "wanting" is mostly evident with the intermittent drug consumption and with long periods of abstinence. Future studies might test how the alcohol "wanting" and the alcohol "liking" change over the alcohol addiction process with a single group of participants, starting with the alcohol dependent group (e.g., DG) that begins a treatment, following the same group trough the abstinence (e.g., AbG). In this way, it could be possible to better understand the changes in the intensity of the "wanting" and "liking" and their prediction of the attentional shift towards the related stimuli.

CONCLUSION

The aim of the present work was to examine the alcohol addiction process from two perspectives, the alcohol related impairment of the mental functions and the alcohol induced incentive sensitization of the specific brain areas. Therefore, the first part was focused on those neuropsychological processes that are more vulnerable to the condition of alcohol dependence, namely the executive functions (i.e., the fluency, the visuo-motor speed, the mental flexibility and the working memory capacity). Importantly, the study conducted in this part of the work, tested the recovery of these functions during a six months period of abstinence trough a change in the performance on the neuropsychological measures. The data confirmed that, for the tested group of participants, the mental flexibility (i.e., assessed with the Trail Making Test part B) together with the working memory capacity (i.e., assessed with the Digit span forward and backward test) improved across the period of alcohol abstinence. The abstinence period was the central part of the recovery program which the participants attended during the six months. The relevance of the current study is associated to the effects of neuropsychological impairments on the efficiency of the recovery program. Thus, the impairment of the executive functions induced by the alcohol could impact the elaboration of the information given during the support program. Therefore, it is important to identify the period of abstinence sufficient for a recovery of the executive functions in order to calibrate the information offered during the program.

The limitation of the study is the elevate sample mortality that reduced the number of participants in the second session. Moreover, the verbal fluency (i.e., measured with the Phonemic and Semantic tests) and the visuo-motor speed measured with the Trail Making test A did not show change significant change in the performance. These results should be compared with a control group of healthy adults (equalized for age, gender and school education) that are in complete abstinence (i.e., never consume alcohol) in order to evaluate the presence and the level of impairment of these neuropsychological functions. This limitation will be considered in the future study where the same data will be collected with a non clinical group of participants in order to compare the data with the clinical sample and in order to have a complete picture of the level of impairment of the executive functions.

The second part considered the key features of the incentive sensitization attributed to the alcohol, the alcohol "wanting" and the alcohol "liking". The predictors of the attentional bias, namely the alcohol "wanting" and the alcohol "liking" were tested across three studies with different groups of alcohol users and with a different oparetivization of these two processes (i.e., the self-relevance of the alcohol and the evaluation of the alcohol). The results indicated the alcohol "wanting" (i.e., the self relevance of the alcohol) and not the "liking", as a predictor of the alcohol related stimuli indicating that the long-term alcohol modifications involves the reward system and not the hedonic component. Importantly, this association emerged in the alcohol abstinent group that used to have alcohol dependence problems, confirming the persistence of these alcohol induced modifications even after the dependence phase. The same prediction model emerged for the alcohol dependent and moderated groups (although fell short of significance). The two perspectives on the effects of the alcohol, namely the neuropsychological impairment and the incentive sensitization were considered separately in the present work. It will be address to the future study to test the association between these two effects of the alcohol and the relation between these processes and the attentional bias toward the alcohol related stimuli, in an alcohol addicted group.

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APPENDIX

Alcohol Use Identification Test (AUDIT) Italian version:

1. Con quale frequenza consuma bevande contenenti alcol?

- ☐ Mai
- ☐ Meno di una volta al mese
- ☐ Da 2 a 4 volte al mese
- ☐ Da 2 a 3 volte a settimana
- ☐ 4 o più volte a settimana

2. Nei giorni in cui beve, quante bevande alcoliche consuma in media?

- ☐ 1 o 2
- ☐ 3 o 4
- ☐ 5 o 6
- ☐ 7 o 8
- ☐ 10 o più

3. Con quale frequenza le capita di consumare sei o più bevande in un' unica occasione?

- ☐ Mai
- ☐ Meno di una volta al mese
- ☐ 1 volta al mese
- ☐ 1 volta a settimana
- ☐ Ogni giorno o quasi

4. Con quale frequenza, durante l'ultimo anno, si è accorto di non riuscire a smettere di bere una volta che aveva iniziato?

- ☐ Mai
- ☐ Meno di una volta al mese
- ☐ 1 volta al mese
- ☐ 1 volta a settimana
- ☐ Ogni giorno o quasi

5. Con quale frequenza, durante l'ultimo anno, non è riuscito a fare ciò che normalmente ci si aspetta da Lei a causa del bere?

- ☐ Mai
- ☐ Meno di una volta la mese
- ☐ 1 volta al mese
- ☐ 1 volta a settimana
- ☐ Ogni giorno o quasi

6. Con quale frequenza, durante l'ultimo anno, ha avuto bisogno di bere di prima mattina per tirarsi su dopo una bevuta pesante?

- ☐ Mai
- ☐ Meno di una volta al mese
- ☐ 1 volta al mese
- ☐ 1 volta a settimana
- ☐ Ogni giorno o quasi

7. Con quale frequenza, durante l'ultimo anno, ha avuto sensi di colpa o rimorso dopo aver bevuto?

- ☐ Mai
- ☐ Meno di una volta al mese
- ☐ 1 volta al mese
- ☐ 1 volta a settimana
- ☐ Ogni giorno o quasi

8. Con quale frequenza, durante l'ultimo anno, non è riuscito a ricordare quello che era successo la sera precedente perché aveva bevuto?

- ☐ Mai
- ☐ Meno di una volta al mese
- ☐ 1 volta al mese
- ☐ 1 volta a settimana
- ☐ Ogni giorno o quasi

9. Si è fatto male o ha fatto male a qualcuno come risultato del bere?

- ☐ No
- ☐ Sì, ma non nell'ultimo anno
- ☐ Sì, nell'ultimo anno

10. Un parente, un amico, un medico o altro operatore sanitario si sono occupati del suo bere o le hanno suggerito di smettere?

- ☐ No
- ☐ Sì, ma non nell'ultimo anno
- ☐ Sì, nell'ultimo anno

C.A.G.E. Questionnaire Italian version:

1. Ha mai sentito il bisogno di bere meno?

(SI) (NO)

2. Le da fastidio che qualcuno la critichi perché beve?

(SI) (NO)

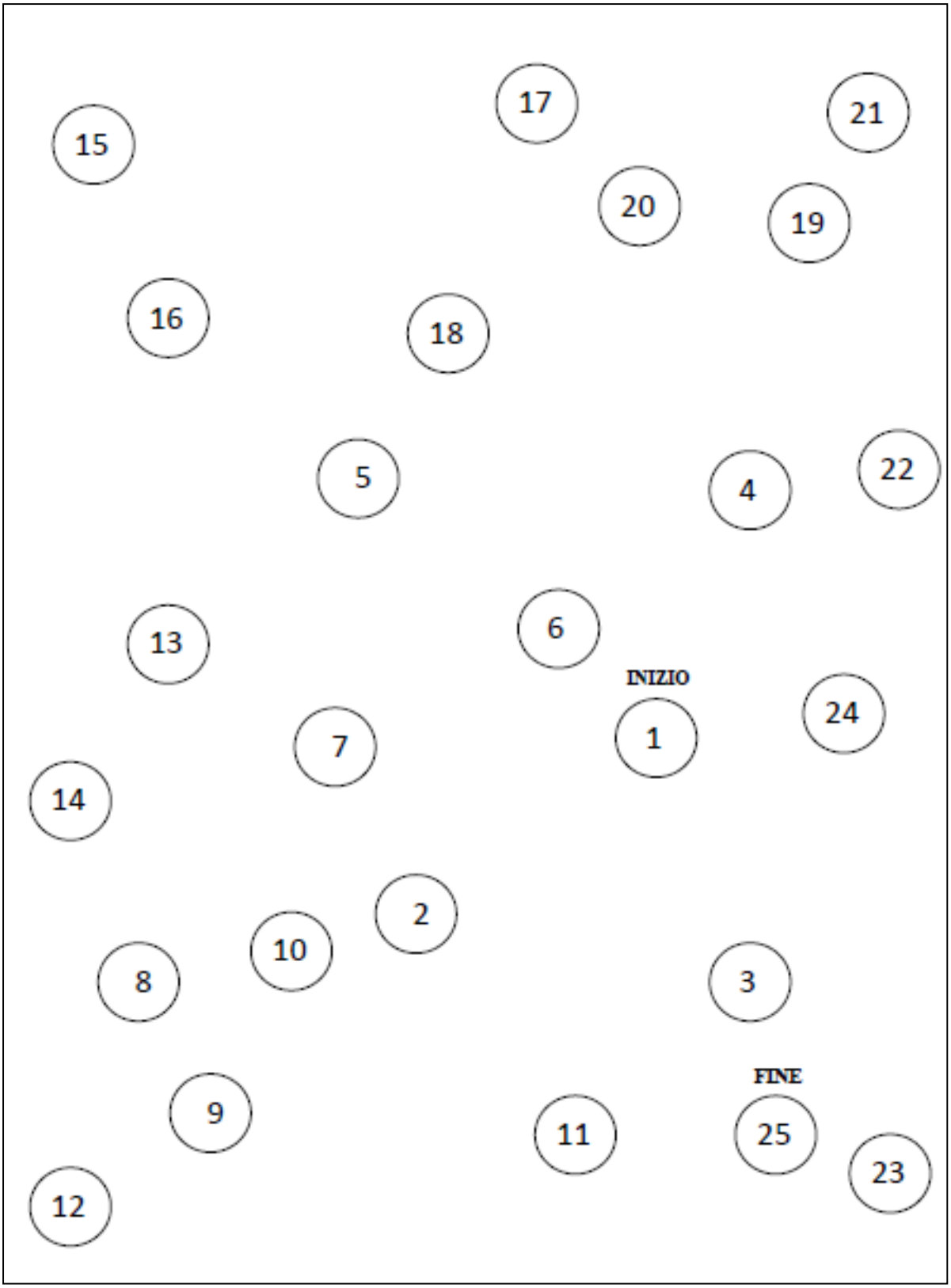
3. Si è mai sentito in colpa perché beve?

(SI) (NO)

4. Le è mai capitato che il bere fosse la prima azione della mattina?

(SI) (NO)

The Trail Making Test Part A.



Trail Making Test Part B.