Alcohol myopia and choice

Alejandro Tatsuo Moreno Okuno[1]
Emiko Masaki[2]

- **Abstract**: The aim of this paper is to develop a model that explains how the consumption of some addictive substances affects individuals' choices and especially how it affects individuals' risk taking. We do this by assuming that some addictives substances, specifically alcohol, increase individuals' discount of the future. As individuals that consume alcohol show greater preference for the present and less for the future, they would find choices with rewards in the present and costs in the future more attractive. Therefore, an individual that wouldn't have accepted an option may do so after consuming alcohol and he/she may regret his/her decision after the alcohol in his/her blood is eliminated. We analyze the effect of two taxes in the welfare of individuals that face an attractive but harmful choice: a tax on the consumption of alcohol and a tax (or penalty) if the future costs of the choice are realized.

- **Resumen:** El objetivo de este artículo es desarrollar un modelo que explique cómo el consumo de ciertas substancias adictivas afecta las elecciones de algunos individuos y en especial cómo afecta su elección bajo incertidumbre. Asumimos que algunas substancias adictivas, específicamente el alcohol, incrementan el descuento futuro de los individuos. Si los individuos muestran mayor preferencia por el presente y menos por el futuro, al consumir alcohol encontrarían más atractivas las opciones con recompensas en el presente y costos en el futuro. Por lo tanto, un individuo que no hubiera aceptado una opción quizás lo haga después de consumir alcohol y se arrepentiría de su decisión después de que el alcohol sea eliminado de su sangre. Analizamos el efecto de dos impuestos en desincentivar una actividad dañina, pero atractiva: un impuesto al consumo de alcohol y un impuesto (o castigo) cuando ocurren los costos futuros de la opción.

- **Keywords:** Habit-formation, risk taking, alcohol consumption.

- JEL **Classification:** D11, D60, D81, D91.

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1 Departamento de Economía y Finanzas. Universidad de Guanajuato. E-mail: atatsuo@hotmail.com
2 Asian Development Bank.
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Introduction

The cost of excessive consumption of alcohol in the US was 223.5 billion dollars in 2006. This represents 746 dollars for each person and 1.90 dollars for each drink served in the US during that period (Bouchery *et al*., 2011). In the case of illicit drugs, the cost was 181 billion dollars in 2002 (Office of National Drug Control Policy, 2004). The cost of excessive consumption of alcohol in the European Union was between 1 and 3% of the GDP, or between 65 and 195 billion dollars per year at 1990 prices (Institute of Alcohol Studies, 2008).

An important part of these costs is attributed to the risky activities that individuals engage under the influence of these substances. For example, the cost of crime and crash related costs committed under the influence of alcohol was 73.3 billion dollars in 2006 (Bouchery *et al*. 2011) and the cost for the treatment of patients with HIV/AIDS related to drug abuse was 2.5 billion dollars in 2002 (Office of National Drug Control Policy, 2004).

Most economists have focused on how the consumption patterns of the users of addictive substances can be congruent with rational behavior. For example, in their seminal article, Becker and Murphy (1988) showed that the explosive consumption patterns of addictive substances can be rationalized by assuming that such consumption accumulates a "stock of capital consumption" that increases the utility from consuming them. Similarly, Dockner and Feichtinger (1993) showed that the cyclical consumption patterns associated with addictive substances can be congruent with rational behavior by assuming that such consumption accumulates not one, but two stocks of capital consumption, for example, an addictive stock and a satiating stock. Berheim and Rangel (2004) assume that drug consumption sensitizes an individual to environmental cues that trigger mistaken usage of drugs. When an individual is exposed to environmental cues related to her previous drug exposure, she enters a "hot mode" where she is compelled to consume drugs again.

Other economists have analyzed the consumption of addictive substances by assuming that individuals are not entirely rational, having time-inconsistent preferences. In these models, taxing addictive substances can increase individuals' welfare. Gruber and Koszegi (2004) analyze cigarette addiction when individuals have present-bias preferences. They show that taxes should be higher in order to include the "internalities" that individuals impose upon themselves. Gruber and Mullainathan (2002) use surveys on self-reported happiness to measure welfare, and conclude that individuals who are predicted to be smokers are happier when taxes on cigarettes are higher.

However, with a few exceptions,[3] economists have ignored that when some individuals are under the influence of alcohol and illegal drugs, they sometimes alter their behavior, often by choosing harmful options they regret when sober. These decisions generally maximize their short-term utility, but are detrimental to their long-term well-being and result in an important cost to society. For example, Robertson and Plant (1988) find a relation between the consumption of alcohol and drugs and the practice of unprotected sex

[3] For a review of the evidence of the effect of alcohol regulation on crime, see Carpenter and Dobkin (2010).

for young adults. And there is considerable evidence on the relation that exists between the consumption of alcohol and crime (Carpenter and Dobkin, 2010).

The aim of this paper is to develop a model that provides an explanation of how the consumption of some addictive substances affects the decision making of some individuals, for example by affecting the risk they are willing to take. We do this by assuming that some addictive substances, specifically alcohol, increase individuals' discount of the future. To the best of our knowledge, this approach has not been used before in the economic literature and, from a public policy perspective, this approach provides some recommendations as to the best way to discourage crime and imprudent behavior of individuals under the influence of drugs and alcohol.

The only other article -that we are aware of- that assumes that the consumption of drugs increases individuals' time discounting is Orphanides and Zervos's (1998). However, they study consumption patterns while we analyze how this increase in time discounting affects individuals' choices. Our model can also be interpreted as allowing individuals to endogeneize their discount of the future, via alcohol consumption. Becker and Mulligan (1997) also allow individuals to endogeneize their discount factor. However, they assume that individuals can invest in reducing the discount rate by "imaging" future consumption, which increases its importance in the present.

Our model is founded on the psychological theory of "alcohol myopia". This theory states that alcohol consumption affects individuals' behavior by limiting their ability to perceive only the more salient cues, that is, those that are more visible and closest in time.[4] As individuals consume alcohol and show greater preference for the present and less for the future, they would find risky choices with rewards in the present and costs in the future more attractive. This could explain the apparent increase in risky behavior of individuals under the influence of alcohol, since the rewards associated with many lotteries are in the present, whilst their costs are in the future.

Numerous psychological studies support the theory of alcohol myopia, and have shown that individuals change their behavior, sometimes by engaging in risky activities when intoxicated with alcohol. For example, Davis *et al*. (2007) find that individuals that are intoxicated with alcohol are more attentive to impelling cues such as sexual arousal, and less so to inhibitory cues, such as sexual risks.

However, if alcohol consumption increases the importance of more immediate cues and reduces that of less immediate ones, as alcohol myopia assumes, then the consumption of alcohol can also increase prudent behavior if the associated costs of a lottery are in the present and the rewards are in the future. MacDonald *et al*. (2000) show that in sexual situations, alcohol-intoxicated individuals reported more prudent intentions than sober ones when strong inhibiting cues were present. For expositional purposes, we will refer to alcohol only when modeling alcohol myopia. However, our model is equally applicable to the consumption of other addictive substances linked to risky behavior. Yoram (2008) analyzes the relation that exists between uncertainty and the

4 The term "alcohol myopia" is from the psychological literature and shouldn't be confused with the term myopia from the present-bias literature, which uses it as an equivalent to naïveté or ignorance about the change of the preferences through time.

discount of the future. Yoram shows that the uncertainty about future events, in opposition to the certainty of the present, can make individuals to behave as if they have a present bias. However, our focus is in the opposite direction, how a change in the future discount (via alcohol consumption) can affect the decision making and in specific the choice of uncertain options.

We introduce our model of alcohol myopia in Section "Alcohol consumption and Choice" by assuming that, as individuals consume alcohol, their discount of the future increases, that is, they give more importance to the present and less to the future. This could be interpreted as a decrease in individuals' rationality, their being less aware of the future consequences of their actions. We work with a two-period model, although we include a third period where individuals don't take any decision, but can receive the payment of the choices taken in the second period. In section "A Numerical Example" we solve a numerical example to show how the consumption of alcohol affects an individual's risk taking. In this example, we show that an individual that anticipates that he/she may choose a harmful lottery, after consuming a certain amount of alcohol, may restrict his/her consumption of alcohol in the first period in order to avoid taking the undesirable lottery in the second period, while an individual that believes (incorrectly) that his/her consumption of alcohol doesn't change his/her risk taking, drinks the amount of alcohol that maximizes their instantaneous utility in the first period and then may choose the undesirable lottery in the second period. In section "Welfare", we discuss the analysis of welfare in our model. In section "Taxes", we analyze the effect of two taxes in discouraging a harmful activity with present rewards and future costs: a tax on the consumption of alcohol and a tax (or penalty) if the future costs of the lottery are realized. In section "An Example of both Taxes", we analyze an example where we compare the benefits and costs of both taxes.

In the last section, we discuss a number of extensions and conclude.

■ *Alcohol consumption and Choice*

In this section, we develop a model that explains how the consumption of alcohol affects individuals' choices. We work with a simple case comprising two periods. In the first period, an individual has to choose how much alcohol to consume and in the second period he/she has to choose from a set of options $(\mathcal{L})$. We include a third period, which serves no purpose other than to allow for the possibility that the payoffs of the choices chosen in the second period are paid in the future.

Given that most costs associated to the change in behavior due to the consumption of alcohol and illegal drugs are given by the choice of risky options, we focus in the election of uncertain options as opposed to certain options. However, alcohol myopia not only affects risky choices, but any choice which benefits and costs are distributed between the present and the future. We analyze lotteries, as lotteries allow us to represent both uncertain and certain choices.

Although the outcomes of a lottery are normally analyzed assuming payoffs which are paid in the present, many lotteries have outcomes whose payoffs are paid at different periods. For example, a lottery might be to have unprotected sex, with one of the possible outcomes being catching a sexually- transmitted disease, the health effects of which are suffered in the future. In the remainder of this article, we will use lotteries over outcomes the payoffs of which may be occurring at different times. To make the lotteries comparable, we have to discount the payoffs that occur in the future. In this case, the preference over the lotteries will depend on the discount of the future of the individuals. By assuming that the amount of alcohol that individuals consume in the first period affect their discount factor when choosing a lottery in the second period, we are assuming that individuals' preferences of the lotteries in the second period may change with their consumption of alcohol in the first period. Therefore, an individual that would not have accepted a lottery may do so after consuming alcohol. If this is the case, he/she may regret his/her decision after the alcohol in his/her blood is eliminated.

Imagine an individual that goes to a bar and decides how much alcohol to drink. After going out of the bar, he/she has two options: having unprotected sex with a stranger he/she met at the bar or not. The first option is a lottery with a present reward, but with the risk of catching a venereal disease which costs are paid in the future. Before drinking any alcohol, he/she has a preference over these activities, preferring for example to be safe and not having unprotected sex. However, his/her preferences may change with his/her consumption of alcohol and he/she may choose to have unprotected sex if he/she is drunk. We rationalize this increase in risk taking by assuming that individuals become more myopic after drinking alcohol, giving less importance to the future consequences of their actions.

Alcohol myopia can be modeled by assuming that alcohol consumption affects the factor β from the present-bias models,[5] or by assuming that it affects the discount factor δ in the standard exponential discount model. In our two-period model, this distinction makes no difference; however, in a model with more periods, this difference may make very different predictions. Nevertheless, we are not yet able to assume either of these is correct, since the psychological evidence on alcohol myopia does not provide any information on whether it affects present bias or the discount factor. Therefore, we will assume that it affects the future discount factor δ, without making any assumption if it is the discount factor from the present bias or the exponential discount. In Appendix II, we define a utility function where alcohol myopia affects the exponential discount factor and a utility function where it affects the present bias.

The vector of consumption in the first period includes two goods: alcohol (a) and the numeraire (y) with the price of the numeraire being one dollar.[6] We assume that the alcohol consumed in the first period remains in the blood during the second period. We denote as $u_1(a,y)$ the instantaneous utility of the first period. We make the usual assumptions for $u_1(a,y)$: $u_{1a}(a,y)>0$, $u_{1y}(a,y)>0$, $u_{1aa}(a,y)<0$ and $u_{1yy}(a,y)<0$.

We assume that there is a physical limitation in the quantity of alcohol an individual can consume. As a result, the utility derived from the consumption of alcohol is also

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5 For an introduction see O'Donoghue and Rabin (1999).

6 Given that the decision between consuming alcohol and the numeraire are made only in the first period, we will write them without any subscript indicating time.

bounded by a constant $\overline{X}$: $u_1(a,y)-u_1(0,y)\leq\overline{X}$ for any a and any y. This contrast to our view of the expected utility of some choices as the payoffs of some of their outcomes can be very large or very negative, as in the case of unprotected sex and crime.[7] For simplicity, we assume individuals don't consume alcohol in the second and third periods, and that their utility is given only by the outcomes of the options chosen, which are given in the numeraire (y).[8] We denote the instantaneous utility in the second and third periods as $u_2(y)$ and $u_3(y)$.

In order to represent that higher consumption of alcohol decreases the attention to the future, we assume that the discount factor in the second period is a function of the alcohol consumed in the first period: $\delta(a)$ and this discount factor is a decreasing function on the amount of alcohol consumed: $\delta'(a) < 0$. For expositional purposes, we assume that $\delta(0) = 1$. This means that, in the first period, individuals do not discount the future, as they haven't consumed alcohol yet. We do this in order simplify our analysis, however, this assumption is not important and can be taken away very easily as it does not change our conclusions.[9] In this article, we will refer to $\delta(a)$ as the "alcohol discount factor." We assume that individuals have von Newmann-Morgenstern utility functions.

In the second period, individuals' perceived expected utility from a lottery L is the expected utility of the outcomes of the lottery for periods two and three, discounted with the alcohol discount factor. I will write this expected utility as $U^2(a,L)$, which is given by the following equation:

$$U^2(a,L) = \sum_{k=1}^{K} \pi_k \left(u_2(y_{2k}) + \delta(a) u_3(y_{3k})\right)$$

where π_k is the probability of outcome k occurring and y_{tk} is the payoff when outcome k occurs at time t. The utility can be negative, as we want to represent lotteries that have a cost in some of their outcomes. We assume that, in the second period, individuals choose the lottery with the highest expected utility, from the point of view of their alcohol discount factor $\delta(a)$.

For clarity, we will write the utility evaluated in the first period as the sum of the instantaneous utility of the first period plus the expected utility from the lottery chosen in the second. As the individual has not consumed alcohol in the first period, he/ she perceives the following utility: $U^1 = u_1 + U^2(0,L)$.

In order to solve the model, we apply the solution concept defined by O'Donoghue and Rabin (1999) to our two-period model. This concept –the "perception-perfect strategy"– is one in which an individual chooses her optimal action in every period based on his/her preferences for the period and his/her perception of his/her future behavior. Following O'Donoghue and Rabin (1999), we analyze the extreme cases where indi-

7 We analyze the case of bounded payoffs in Proposition 2.

8 In order to be consistent with the instantaneous utility of the first period, we could allow the payoffs of the lotteries to be also in alcohol; however, this would complicate the model unnecessarily.

9 It would be more realistic to assume instead that individuals discount the future, even if they haven't consume alcohol, that is $\delta(0) = \overline{\delta}$ where $\overline{\delta} < 1$. However, this wouldn't change our conclusions and would complicate the analysis unnecessarily.

viduals are naïve or sophisticated and compare these with standard consumers that have no future discount affected by his/her consumption of alcohol and whom we will refer to as temporal-consistent agents (TC). As it is standard, we regard naïve agents (naifs) as those that do not realize that their future discount changes, in this case due to alcohol consumption, while sophisticated agents (sophisticates) are those individuals that are fully aware of how their future discount changes with alcohol consumption. We also analyze partially naïve agents, defined by O'donoghue and Rabin (2001) as those individuals that are aware of their self control problems, but not completely aware.

We define the perception-perfect strategy for the three types of agents we are going to analyze. For a TC agent, the future discount is not affected by the amount of alcohol in his/her blood and therefore, in the first period, he/she consumes the amount of alcohol that maximizes his/her instantaneous utility.

Definition 1: a perception-perfect strategy for TCs is a strategy $\left(a^{TC}, y^{TC}, L^{TC}\right)$, that satisfies: $u_1\left(a^{TC}, y^{TC}\right) \geq u_1(a, y)$ and $U^2\left(0, L^{TC}\right) \geq U^2(0, L)$ for all a and y that satisfy $p_a \cdot a + y \leq m$ and all $L \in \mathcal{L}$.

Where m is the income of the individual in the first period and p_a is the price of alcohol.

Although a naif's future discount is affected by his/her consumption of alcohol, he/she is unaware of this and behaves like a TC, consuming the amount of alcohol that maximizes his/her utility for the first period, without taking into consideration that his/her behavior in the second period may change with his/her consumption of alcohol. However, once in the second period, his/her present bias changes and he/she chooses the lottery with the highest expected utility from the perspective of his/her alcohol future discount.

Definition 2: a perception-perfect strategy for naifs is a strategy $\left(a^n, y^n, L^n\right)$, that satisfies: $u_1\left(a^n, y^n\right) \geq u_1(a, y)$ and $U^2\left(a^n, L^n\right) \geq U^2\left(a^n, L\right)$ for all a and y that satisfy $p_a \cdot a + y \leq m$ and $L \in \mathcal{L}$.

Sophisticates are aware that their future discount in the second period is affected by their consumption of alcohol in the first period, and in the first period they consume the amount of alcohol that maximizes the sum of their utility in all periods.

Definition 3: a perception-perfect strategy for sophisticates is a strategy $\left(a^S, y^S, L^S\right)$, that satisfies: $U^1\left(a^S, y^S, L^S\right) \geq U^1\left(a, y, L^S\right)$ subject to $L^S \in \operatorname{argmax}_{L \in \mathcal{L}} U^2(a, L)$ for all a and y that satisfy $p_a \cdot a + y \leq m$.

O'donoghue and Rabin (2001) introduce the concept of a partially naïve agent as an individual who is aware of his/her present-bias, but only partially aware. We adapt their definition to our model of alcohol myopia by assuming that a "partially naïve agent with a perceived discount $\hat{\delta}(a)$" is an individual whose discount factor is $\delta(a)$, but that believes that it is $\hat{\delta}(a)$, where $\hat{\delta}(a) > \delta(a)$ for all a. A partially naïve agent recognizes that his/her consumption of alcohol will increase his/her discount of the future, but underestimates how much it will increase it.

Definition 4: a perception-perfect strategy for a partially naïve agent with perceived alcohol discount $\hat{\boldsymbol{\delta}}(a)$, but a true alcohol discount $\delta(a)$ is a strategy (a^{pn}, y^{pn}, L^{pn}) that satisfies: $U^1(a^{pn}, y^{pn}, \hat{\boldsymbol{L}}) \geq U^1(a, y, \hat{\boldsymbol{L}})$ subject to $\hat{\boldsymbol{L}} \in argmax_{L \in \mathcal{L}} \sum_{k=1}^{K} \boldsymbol{\pi}_k \left(\boldsymbol{u}_2(\boldsymbol{y}_{2k}) + \hat{\boldsymbol{\delta}}(\boldsymbol{a}^{pn}) \boldsymbol{u}_3(\boldsymbol{y}_{3k}) \right)$ for all a and y that satisfy $p_a \cdot a + y \leq m$ and $L^{pn} \in argmax_{L \in \mathcal{L}} \sum_{k=1}^{K} \boldsymbol{\pi}_k (\boldsymbol{u}_2(\boldsymbol{y}_{2k}) + \boldsymbol{\delta}(\boldsymbol{a}^{pn}) \boldsymbol{u}_3(\boldsymbol{y}_{3k}))$.

In order to guarantee the existence of a perception-perfect strategy, we assume that if an individual is indifferent between both lotteries, he/she chooses the one he/she would have chosen had he/she not consumed alcohol.

In the following section, we make a numerical example to show how the consumption of alcohol can affect the risk taking and how the behavior of a naif differs from that of a sophisticate and partially naïve.

A numerical example

In this section, we develop a numerical example to illustrate how the consumption of alcohol affects the choices of an individual and how, if he/she anticipates this, he/she will decrease his/her consumption of alcohol in order to avoid choosing an option he/she does not want to take. We assume that the instantaneous utility function in the first period is $u_1(a, y) = \ln(a) + y$, the income in the first period is two dollars and the price of alcohol is one. We assume that the alcohol discount factor is given by the following equation: $\delta(a) = 1/(1 + a)$. We work with a simple example of two lotteries, the first with two outcomes whose payoffs are paid in both the second and third periods, and a second lottery that has only one outcome. For simplicity, we give the payoffs already in utility values.

Alcohol myopia can increase risk taking. The first lottery gives a utility of 1 for sure in the second period; however, in the third period it gives a utility of -3 with probability of 1/2 and 0 with probability of 1/2.

The second lottery gives a utility of 0 for sure in both periods. The payoffs for both lotteries are shown in Table 1.

Table 1
Payoffs for lotteries 1 and 2

	Payoff in Period 2	Payoff in Period 3
Lottery 1	1	(-3,0;1/2,1/2)
Lottery 2	0	0

Note that when no alcohol is consumed in the first period, the discount factor is one and with this discount factor, the second lottery is preferred to the first one. To see this, notice that the expected utility of the first lottery is -0.5 with $\delta(0) = 1$, while the expected utility of the second lottery is 0.

The perception-perfect strategy for a naif is to consume one unit of alcohol in the first period and then choose the first lottery in the second. A naif would maximize his/her instantaneous utility in the first period (as he/she doesn't realize that his/her consumption of alcohol affects his/her election of lotteries in the second period) by dividing his/her income equally between alcohol and the numeraire, and have an amount of alcohol in the blood of one in the second period. With this amount of alcohol, his/her future discount in the second period would be one half and he/she would choose the first lottery (the risky lottery with future costs), given that this lottery's expected value has now increased for his/her to 0.25, and the second lottery's expected value continues to be zero.

The perception-perfect strategy for a sophisticate is to consume 1/2 of a unit of alcohol in the first period and to choose the first lottery in the second. A sophisticate would anticipate that his/her consumption of alcohol in the first period would increase his/her future discount in the second. He/she knows that if he/she drinks more than 1/2 of a unit of alcohol in the first period he/she would take the first and risky lottery in the second period. Given that he/she loses more by taking the risky lottery than the utility he/she gains by consuming alcohol, he/she would limit her consumption of alcohol to just 1/2, just enough to not take the risky lottery in the second period.

The perception-perfect strategy for a partially naïve with a perceived alcohol discount $\hat{\delta}(a) = 3/(3 + 2a)$, but a true alcohol discount of $\delta(a) = 1/(1 + a)$ is to consume 3/4 units of alcohol in the first period and to take lottery 1 in the second period. A partially naïve would anticipate that his/her consumption of alcohol in the first period would increase his/her future discount in the second period. However, he/she under appreciates this change, believing, erroneously, that limiting her consumption of alcohol to 3/4 would be enough to avoid taking the lottery 1 in the second period. However, with this consumption of alcohol, he/she chooses the lottery anyway.

Alcohol myopia can reduce risk taking. As mentioned in the introduction, if alcohol myopia increases the importance of more immediate cues and reduces the importance of less immediate ones, then the consumption of alcohol can also reduce risk taking if the costs of a lottery are in the present and rewards are in the future. For example, lottery 3 below has costs in the present and rewards in the future.

Table 2
Payoffs for lotteries 3 and 4

	Payoff in Period 2	Payoff in Period 3
Lottery 3	-1	(3,0;1/2,1/2)
Lottery 4	0	0

An individual that has consumed alcohol may avoid lottery 3. In this case, alcohol myopia makes individuals act more prudent, even if they are better off by taking lottery 3, since its expected payoffs are positive.

The perception-perfect strategy for a naif is to drink one unit of alcohol in the first period and to avoid lottery 3 in the second period. Naifs consume the amount of alcohol that maximizes their instantaneous utility in the first period: one unit of alcohol and with this amount of alcohol they choose lottery 4.

Sophisticates anticipate in the first period that if they drink too much alcohol they will avoid lottery 3 in the second period and they limit their consumption of alcohol to 1/2 units of alcohol, just the amount of alcohol they won't avoid lottery 3.

The perception-perfect strategy for a partially naïve with a perceived alcohol discount $\hat{\delta}(a) = 3/(3 + 2a)$, but a true alcohol discount of $\delta(a) = 1/(1 + a)$ is to consume 3/4 of alcohol in the first period and choose lottery 4 in the second period. A partially naïve under-appreciates his/her alcohol discount and believes that limiting his/her consumption of alcohol to 3/4 would be enough to not avoid lottery 3 in the second period. However, he/she is mistaken and with this amount of alcohol he/she still avoids lottery 3.

Welfare

In our model, welfare comparisons are problematic, given that the utility function varies with the consumption of alcohol. Following O'Donoghue and Rabin (1999), we measure welfare using a fictitious period 0 that represents the long-term perspective by weighting all periods equally (in our model, we weight all periods without the discounting factor from alcohol consumption): $U^0(a,y,L) \equiv u_1(a,y) + U^2(0,L)$. Using this fictitious period 0, we measure the welfare loss as the difference in utility from any deviation with respect to the optimal solution, which is given by the perception-perfect strategy for a TC agent. For example, the welfare loss for a naif is given by $U^0(a^{TC},y^{TC},L^{TC}) - U^0(a^n,y^n,L^n)$.

In the following proposition, we show that the welfare losses caused by alcohol are limited by sophistication. As the example above shows, a sophisticate would anticipate that his/her consumption of alcohol may affect his/her valuation of lotteries in the second period, and would limit his/her consumption of alcohol if the expected losses associated with the consumption of alcohol are higher than the utility from consuming it. This would limit the welfare losses for a sophisticate to the highest utility he/she can get from consuming alcohol: $\overline{X}$. However, for a naif, the welfare losses can be as high as the expected utilities of the lotteries involved.

Proposition 1: (1) For any lottery, the welfare loss caused by the consumption of alcohol for the sophisticates: $U^0(a^{TC},y^{TC},L^{TC}) - U^0(a^S,y^S,L^S)$, is bounded by $\overline{X}$; and (2) for a naif, we can always find a lottery for which the welfare loss caused by the consumption of alcohol: $U^0(a^{TC},y^{TC},L^{TC}) - U^0(a^n,y^n,L^n)$, is higher than any constant C.

All proofs are in the Appendix.

Proposition 1 suggests that the government should focus on policies that benefit naifs, since the welfare losses for the latter can be much higher than those for sophisticates.

We have to be careful, as Proposition 1 is based on the assumption that there are lotteries with very high payoffs. Although for some lotteries it is reasonable to assume that the payoffs in a single period can be very low, as some lotteries include the possibility of death, it is less reasonable to assume that the payoffs in a single period can be arbitrarily high. Proposition 2 consider lotteries which payoffs cannot be arbitrarily high and are bounded from above.

Proposition 2: Let $\underline{\delta}$ be the lower bound of the alcohol discount factor, for lotteries with payoffs bounded from above by a constant $\overline{\nu}$, the welfare loss caused by the consumption of alcohol is lower than $\overline{\nu}/\underline{\delta} - \overline{\nu}$.

In reality, however, after the consumption of alcohol, many individuals accept choices which costs in the future may be arbitrarily high, but which benefits in the present are bounded. For this to happen in our model, the alcohol discount factor for these individuals has to become very small after the consumption of alcohol.

Proposition 3 compares the welfare of two partially naïve agents, different only in their degree of naïveté.

Proposition 3: For lotteries with expected utility lower than $-\overline{X}$ from the point of view of a TC agent $\left(U^2(0,L) \leq -\overline{X}\right)$ the welfare for a partially naïve agent with a perceived discount $\hat{\delta}(a)$ and a true alcohol discount of $\delta(a)$ is weakly lower than for a partially naïve agent with a perceived discount $\hat{\delta}(a)$ and a true alcohol discount of $\hat{\delta}'(a)$, if $\hat{\delta}(a) < \hat{\delta}'(a)$ for all a.

This result shows that when facing harmful lotteries, the more aware an individual is of her alcohol myopia, the worst he/she is. As long as he/she is not fully aware of how much alcohol affects his/her preferences in the second period, he/she limits her consumption of alcohol when facing an attractive, but harmful lottery, but not enough to avoid choosing it in the second period. The more aware he/she is of her alcohol myopia, the more he/she would limit his/her alcohol consumption, and the more costly it will be for him/her, but always futilely.

In the following section, we analyze two types of taxes in order to discourage a risky activity. The first one is a tax on the consumption of alcohol and the second one is a tax on the future outcomes of risky lotteries.

Taxes

As we mentioned earlier, individuals that have consumed alcohol may choose attractive options only to regret them when sober. These are options with rewards in the present and costs in the future with a welfare loss from the point of view of TC agents. The welfare loss of some of these choices is so high that governments try to discourage them, as it is the case of unprotected sex, driving under the influence of alcohol or crime.

In this section, we analyze the effects of two types of taxes in the welfare of a sophisticate and a naif. The first tax is a tax on the price of alcohol (T_a), that is paid when alcohol is consumed in period one and the second tax is a tax paid if the future costs of the lotteries are realized in period three $(T_{\mathcal{L}})$. The reason for assuming that the tax on the lottery is paid in period three as opposed to period two is that we believe that the government normally finds out if an individual has engaged in a harmful activity only when some of the future costs of the lottery are realized[10] and because the penalties the government can impose are paid in the future, as it is jail time for a crime. For simplicity, we assume that there is only one lottery and individuals have to choose if they take it or not.

The following proposition shows that a tax on the price of alcohol reduces the welfare for a sophisticate, while a tax on the future costs of a lottery may increase the welfare of a sophisticate if the lottery has a low enough expected utility from the point of view of a TC agent. The reason for this is that a sophisticate is able to correctly predict his/her self control problems and limits his/her amount of alcohol he/she consumes in the first period, even without a tax. A tax on the price of alcohol only increases the price he/she has to pay to consume alcohol. However, a tax on the future costs of a lottery with a low enough expected utility from the perspective of a TC will reduce the attractiveness of the lottery. Anticipating this, he/she may be able to increase her consumption of alcohol in the first period, knowing that he/she won't take a risky and now less attractive lottery.

Proposition 4: (1) A tax on alcohol weakly decreases welfare for a sophisticate and this welfare loss is lower than $\overline{X}$; and (2) a tax on the future costs of lotteries with expected utility lower than $-\overline{X}$ from the point of view of a TC agent $\left(U^2\left(0,L\right)\leq-\overline{X}\right)$, weakly increases the social welfare for a sophisticate, and this gain in social welfare is lower than $\overline{X}$.

In contrast to sophisticates, naifs can benefit from a tax on the price of alcohol. Naifs drink the amount of alcohol that maximizes their instantaneous utility without realizing that their preferences over choices are going to be affected by their alcohol consumption. When the cost of these choices is too high, a tax on the future costs may not be enough to discourage these choices, but a tax on alcohol may do it.

Proposition 5 shows that any tax on alcohol has a welfare loss of at most $\overline{X}$ for naifs. However, the welfare gains from a tax on alcohol may be very high, as taxes on alcohol reduce the consumption of alcohol and may discourage naifs from taking lotteries with very high welfare losses.

Proposition 5: (1) The welfare loss for a naif from a tax on alcohol is bounded by $\overline{X}$; and (2) the welfare gain for a naif from a tax on alcohol is not bounded by any constant.

We cannot say anything about the welfare implications of a tax on the future consequences of a lottery, given that the lottery can have a positive or negative expected utility from the point of view of the TC agent. Therefore, a tax on the future consequences can have a welfare loss or gain. However, when we consider only harmful lotteries, a tax on the future consequences may be the optimal tax if it helps naifs avoid the lottery as it also increases the utility of the sophisticates (as they can increase their consumption of alcohol in the first period knowing that the lottery in the second period is less attractive.) However, a tax on the future consequences is normally difficult to implement as some of the future consequences may be catching venereal diseases or being involved in an accident.

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10 Think of driving under the influence of alcohol or committing a crime.

An example of both taxes

In this section, we develop an example in order to compare the costs and benefits of both taxes in helping a naif avoid a harmful but attractive lottery. First, we show that the optimal tax on the future consequences of the lotteries $(T^*_{\mathcal{L}})$ benefits both naifs and sophisticates. However, this tax is not easy to implement. When a tax on the future consequences is not possible to implement, a tax on alcohol consumption (T_a) may be the second best option. A tax on the consumption of alcohol, although benefits naifs, harms sophisticates.

Let's assume that a proportion α of the population are sophisticates while the rest $(1-\alpha)$ are naifs. Let's make the same assumptions than the example in section Alcohol myopia can increase risk taking: the alcohol discount function is $\delta(a) = 1/(1+a)$ and the instantaneous utility in the first period is $u_1 = \ln(a) + y$, the price of alcohol and y is one and the income in the first period is two. When there is no tax, the consumption of alcohol for a naif (a^n) is one, as he/she consumes the amount that maximizes his/her instantaneous utility in the first period.

Let´s assume that individuals are facing a harmful, but attractive lottery: a lottery with a negative expected utility from the point of view of a TC $(\nu - c < 0)$, but a positive expected value for somebody that has drunk the optimal amount of alcohol for the first period $(\nu - \delta(a^n)\cdot c > 0)$. Let's also assume that the cost of the lottery is such that it is worth sacrificing the consumption of alcohol in the first period in order to avoid the lottery in the second period. The consumption of alcohol for a sophisticate (a^s) is that which allows his/her to avoid taking the harmful lottery in the second period: $a^S = \frac{c-\nu}{\nu}$.

A tax on the future costs of the lottery. An optimal tax on the future costs of the lottery would make the future costs high enough that the lottery would become unattractive for naifs, helping them in avoiding the lottery, that is $\nu - \delta(a^n)\cdot(c + T^*_{\mathcal{L}}) \leq 0$. Solving for $T^*_{\mathcal{L}}$ we get that $T^*_{\mathcal{L}} \geq \nu/\delta(a^n) - c$. (We have to note that there are many optimal taxes, as every tax that allows individuals to avoid the lottery is optimal.) The benefit of this tax for a naif is $c - \nu$ as she avoids the lottery, which expected value is negative.

This tax also benefits sophisticates as they can drink the amount of alcohol that maximizes their instantaneous utility in the first period, knowing that the tax will help them avoid the lottery in the second period even after the consumption of alcohol. The benefit of this tax is given by the extra utility that sophisticates get in the first period by not limiting their alcohol consumption in the first period: $u_1(a^S) - u_1(a^n)$.

However, it is often impossible to implement a tax on the future consequences of a lottery, as some of these consequences are catching venereal diseases or having an accident. In this case, a tax on the consumption of alcohol may be the second best option.

Tax on alcohol consumption. The optimal tax on alcohol consumption would make the consumption of alcohol costly enough for naifs to limit their consumption to an amount in which they avoid taking the harmful lottery in the second period.

A naif consumes the amount of alcohol that maximizes his/her instantaneous utility in the first period, that is the amount where the marginal utility from each unit of income spent is the same for both alcohol and the numeraire, that is: $\frac{UM_g(a)}{UM_g(y)} = \frac{P_a + T_a}{P_y} = \frac{1 + T_a}{1}$.

Solving for T_a we get the size of the tax as a function of the amount of alcohol we want naifs to consume: $T_a = 1/a - 1$. Given that the highest consumption of alcohol for which naifs avoid the lottery is $a = \frac{c - \nu}{\nu}$, the optimal tax on the price of alcohol is $T_a^* = \frac{2\nu - c}{c - \nu}$.

The instantaneous utility in the first period decreases for naifs with the tax on the consumption of alcohol as a naif reduces his/her consumption of alcohol from the amount that maximizes the instantaneous utility (one unit of alcohol) to the amount that allows his/her to avoid the lottery in the second period $\left(a^S\right)$. The benefits of avoiding the lottery are given by: $c - \nu$. The benefit for the naif from the optimal tax on alcohol is the benefit of avoiding the harmful lottery, less the loss in the instantaneous utility in the first period caused by the tax: $c - \nu - ln\left(\frac{c - \nu}{\nu}\right)$.

Sophisticates anticipate the effect that alcohol has on their choice of a lottery in the second period and reduce the amount of alcohol they consume to the point in which they avoid the harmful lottery. A tax on alcohol does not affect their consumption of alcohol, as they are already consuming below their optimal consumption for period one. However, a tax on alcohol affects their consumption of the numeraire, y. Therefore, the cost for the sophisticates from the tax on the consumption of alcohol is given by the amount the consumption of the numeraire is reduced, which is given by the tax that the sophisticates pay: $C^S = a^S \bullet T_a^* = \left(\frac{c - v}{v}\right)\left(\frac{2v - c}{c - v}\right) = \frac{2v - c}{v}$.

It is optimal to tax the consumption of alcohol if the proportion of naifs is high and the benefits from the tax for naifs is higher than the cost from the tax for sophisticates, which happens if the following inequality holds: $\alpha \frac{2v - c}{v} \leq (1 - \alpha)\left(c - v - \ln\left(\frac{c - v}{v}\right)\right)$, otherwise, it is better to not tax alcohol, as the benefits for naifs from avoiding the lottery are lower than the reduction in utility for the sophisticates.

Our model is too simple to give credible policy recommendations. However, our results suggest that when there are harmful choices that the government wants to discourage and a tax on the future consequences cannot be implemented, a tax on alcohol may be a good option. Although taxing alcohol may harm sophisticates, the welfare gains for naifs can be much higher than the harm for sophisticates.

▪ *Conclusions*

In this article we developed a model of alcohol myopia that explains some of the change in behavior that is associated with addictive substances by assuming that these substances increase individuals' discount of the future.

However, certain aspects of our analysis should be treated with caution.

Firstly, as we saw in the introduction, the psychological evidence shows that alcohol myopia not only increases an individual's attention to cues that are in the present, but also increases his/her attention to visible cues. By not including this aspect in our model, we are providing only a partial explanation of alcohol myopia, and omitting a number of elements that could result in better policy advice.

Secondly, we are not considering the habit-formation aspect of alcohol consumption as it is usually the case in the literature on addictive substances. However, we do not regard this as a fundamental flaw of our model, since habit-formation occurs over a period that is longer than that normally involved in an isolated case of alcohol consumption, which is the case in the scope of our article.

There are a number of future extensions that can be made. First, a model with more periods would allow us to analyze certain aspects that we have not been able to consider in our three-period model, such as the "sophistication effect" introduced by O'Donoghue and Rabin (1999). This effect refers to when sophisticates are aware of their future self-control problems and react by exacerbating them. In our model, the sophistication effect would be that sophisticates anticipate that they will consume alcohol in the future, and so conclude that there is no case for them to limit their alcohol consumption in the present. Once we consider this effect, it may prove to be the case that sophisticates sometimes consume more alcohol than naifs.

Finally, we can extend our analysis to how individuals use the consumption of addictive substances to diminish the anxiety associated with the anticipation of future events.

■ *Appendix I*

Proof of Proposition 1

(1) Note that in the first period, a sophisticate has always the option of consuming zero amount of alcohol, in which case he/she would face the same maximization problem as a TC agent in the second period and therefore he/she would choose the same lottery. His/her welfare loss with respect to a TC agent would come from the difference in utility from not consuming alcohol in the first period, which is bounded by $\overline{X}$. Because the sophisticate has always this option, he/she would never choose a higher amount of alcohol that gives him/her a lower overall utility.

(2) We prove it with an example. Because we assume that the instantaneous utility function is continuous and unbounded, we can find a lottery that pays any payoffs. Suppose that there are two lotteries, lottery one, L_1, that pays a utility of $\delta(a^n)\cdot(3C)/(1-\delta(a^n))+C$ for sure in the second period and zero in the third period and a second lottery, L_2, that pays a utility zero in the second period and a utility of $(3C)/(1-\delta(a^n))$ for sure in the third period. In the first period, the naif does not realize that his/her consumption of alcohol affects his/her decision in the second period and consumes the amount of alcohol that maximizes his/her instantaneous utility for that period: a^n. In the second period, the naif, after consuming a^n units of alcohol in the first period chooses lottery L_1. The welfare loss for the naif for taking lottery L_1 instead of L_2 is $2C$.

Proof of Proposition 2:
We will show that an individual facing a lottery with benefits in the second period of $\overline{v}$ has an upper bound to their social welfare loss of $\overline{v}/\underline{\delta} - \overline{v}$.

An individual with an alcohol discount factor of $\delta(a)$ would consume a lottery only if the expected payoff of the lottery is positive: $\overline{v} - \delta(a) \cdot c > 0$. If a lottery has payoffs bounded from above by a constant $\overline{v}$, the lotteries are accepted only for values of c lower than $\overline{v}/\delta(a)$ and the welfare loss for accepting these lotteries is lower than $\overline{v}/\delta(a) - \overline{v}$. Given that $\underline{\delta}$ is the lower bound for $\delta(a)$, the welfare loss is lower than $\overline{v}/\underline{\delta} - \overline{v}$.

Proof of Proposition 3:
For the case of a lottery with an expected utility lower than $-\overline{X}$ from the point of view of a TC agent, a partially naïve agent with a perceived discount $\hat{\boldsymbol{\delta}}(a)$would limit his/her consumption of alcohol if he/she believes that he/she will take the lottery if he/she consumes the amount of alcohol that maximizes his/her instantaneous utility in the first period, that is if the expected utility of the lottery with the amount of alcohol a^n is greater than zero: $\sum_{k=1}^{K} \boldsymbol{\pi}_k \left(\boldsymbol{u}^2(\boldsymbol{y}_{2k}) + \hat{\boldsymbol{\delta}}(a^n)\boldsymbol{u}^3(\boldsymbol{y}_{3k})\right) > 0$. For this to happen, it must be a lottery with present benefits and future costs. Both partially naïve agents consume the amount of alcohol that allows them to avoid this lottery, that is the amount $\hat{\boldsymbol{a}}$ for the agent $\hat{\boldsymbol{\delta}}$ that makes $\sum_{k=1}^{K} \boldsymbol{\pi}_k \left(\boldsymbol{u}^2(\boldsymbol{y}_{2k}) + \hat{\boldsymbol{\delta}}(\hat{\boldsymbol{a}})\boldsymbol{u}^3(\boldsymbol{y}_{3k})\right) = \mathbf{0}$ and the amount $\hat{\boldsymbol{a}}'$ for the agent $\hat{\boldsymbol{\delta}}'$ that makes $\sum_{k=1}^{K} \boldsymbol{\pi}_k \left(\boldsymbol{u}^2(\boldsymbol{y}_{2k}) + \hat{\boldsymbol{\delta}}'(\hat{\boldsymbol{a}}')\boldsymbol{u}^3(\boldsymbol{y}_{3k})\right) = \mathbf{0}$. This results in their perceived alcohol discount factor of the second period being the same for both individuals, that is: $\hat{\boldsymbol{\delta}}(\hat{\boldsymbol{a}}) = \hat{\boldsymbol{\delta}}'(\hat{\boldsymbol{a}}')$. Given that $\hat{\boldsymbol{\delta}}(\boldsymbol{a})$ and $\hat{\boldsymbol{\delta}}'(\boldsymbol{a})$ are decreasing functions on a, and that $\hat{\boldsymbol{\delta}}(\boldsymbol{a}) < \hat{\boldsymbol{\delta}}'(a)$ for all a, we must have that $\hat{\boldsymbol{a}} > \hat{\boldsymbol{a}}'$.

However, given that their true alcohol discount is $\delta(a)$, which is lower than $\hat{\boldsymbol{\delta}}(\boldsymbol{a})$and $\hat{\boldsymbol{\delta}}'(a)$ for any amount a, and that it is a lottery with present benefits and future costs, he/ she would take the lottery anyway, as the expected utility of the lot tery is greater than zero for both agents: $\sum_{k=1}^{K} \boldsymbol{\pi}_k (\boldsymbol{u}^2(\boldsymbol{y}_{2k}) + \boldsymbol{\delta}(\hat{\boldsymbol{a}})\boldsymbol{u}^3(\boldsymbol{y}_{3k})) > \mathbf{0}$ and $\sum_{k=1}^{K} \boldsymbol{\pi}_k \left(\boldsymbol{u}^2(\boldsymbol{y}_{2k}) + \hat{\boldsymbol{\delta}}'(\hat{\boldsymbol{a}}')\boldsymbol{u}^3(\boldsymbol{y}_{3k})\right) > \mathbf{0}$. Therefore, every partially naïve agent takes the lottery in the second period, even as they limit the amount of alcohol they consume in the first period. Therefore, any difference in welfare for both partially naïve agents is due to their alcohol consumption in the first period.

Because they are limiting their consumption of alcohol with respect to the amount that maximizes their instantaneous utility in the first period, the less they limit their consumption, the better they are. Given that the partially naïve agent with perceived discount $\hat{\boldsymbol{\delta}}(\boldsymbol{a})$ is limiting his/her consumption of alcohol less than the partially naïve agent with perceived discount $\hat{\boldsymbol{\delta}}'(a)$ he/she must be better off.

Proof of Proposition 4

(1) Let's call $(a^{TaS}, y^{TaS}, L^{TaS})$ as the optimal amount of alcohol, numeraire and lottery for a sophisticate when there is a tax T_a on alcohol. Note that when there is no tax on alcohol the sophisticate has always the choice of consuming the same amount of alcohol, and the same lottery with a higher amount of the numeraire: $(a^{TaS}, y^{TaS} + T_a \cdot a, L^{TaS})$. Because the sophisticate has always this option, he/she has a weakly higher utility when there is no tax on alcohol. The sophisticate has always the option of drinking no alcohol in the first period and because the welfare loss of this option is bounded by $\overline{X}$, he/she can always choose this option and avoid any welfare loss higher than $\overline{X}$ from a tax on alcohol.

(2) If $U^2(0, L) < -\overline{X}$, the cost of choosing lottery L is higher than the utility from consuming alcohol, and therefore the sophisticate is going to limit his/her amount of alcohol in the first period if he/she believes he/she will take the lottery if consumes the amount of alcohol that maximizes his/her instantaneous utility in the first period. As any positive tax on future costs weakly reduces the expected utility of L, the individual can increase her consumption of alcohol as the attractiveness of the lottery has been reduced. Given that he/she was consuming less than the amount of alcohol that maximizes his/her instantaneous utility for the first period, he/she would increase his/her consumption of alcohol, increasing his/her utility.

Proof of Proposition 5:

(1) We prove it by showing that a tax on alcohol reduces the welfare in the first period at most in $\overline{X}$ and show that it may increase the welfare of the lottery chosen in the second period, as individuals that consume less alcohol choose lotteries that have a higher utility from the point of view of the TC agents.

First period. A naif consumes the amount of alcohol that maximizes his/her utility in the first period. This amount of alcohol is given by the following first order conditions: $u'(a^n) = p_a$ when there is no tax and $u'(a^{Tam}) = p_a + T_a$ when there is a tax T_a on the price of alcohol. Because $u(a)$ is a decreasing function on $a, a^n \geq a^{Tan}$.

In the first period, as the tax on alcohol moves the naif from his/her optimal consumption of alcohol, his/her instantaneous utility decreases. However, he/she always has the option of not consuming alcohol and not paying any tax, in which case his/her utility decreases at most in $\overline{X}$. Because the naif has always this option, he/she cannot do worst than this.

Second period. Now we show that a tax on alcohol weakly increases the welfare from the lottery chosen in the second period.

Let's call x_i as the expected utility of all the payoffs of lottery i paid in the second period (as seen in the second period) and z_i as the expected utility of all the payoffs of lottery i paid in the third period (as seen in the third period). If we call lottery L_a as the lottery chosen by a naif after a consumption of alcohol a in period one, then we have inequality $1: x_a + \delta(a)z_a \geq x_i + \delta(a)z_i$ for any $i \in \mathcal{L}$. If, after the imposition of tax T_a, the naif consumes the amount of alcohol $a^{Tan} \leq a^n$ in the first period and chooses a lottery L_{Tan} different than L_a in the second period and we have inequality 2: $x_{Tan} + \delta(a^{Tan})z_{Tan} \geq x_a + \delta(a^{Tan})z_a$. By adding inequalities 1 and 2 we get that $z_{Tan} \geq Z_a$ and, therefore, we know that $\delta(a^{Tan})z_{Tan} \geq \delta(a^{Tan})z_a$. If we add this last inequality to inequality 1, we get that $x_{Tan} + z_{Tan} \geq x_a + z_a$ and therefore the welfare from the lottery chosen when there is a tax on alcohol is weakly higher as compared with the case where there isn't one.

(2) We prove it with an example. Suppose that there is only one lottery, one that pays $C \cdot \delta(a^{Tan})$ for sure in the first period and $-C$ for sure in the third period. If a^n is positive, then $a^n > a^{Tan}$ and $\delta(a^n) < \delta(a^{Tan})$. Therefore, he/she would take the lottery if there is no tax on alcohol, but he/she wouldn't take it if there is a tax on alcohol T_a. Therefore the tax gives a naif a welfare gain of $C(1 - \delta(a^{Tan}))$. Because this is true for any $C > 0$ and any tax T_a the welfare gain of a tax on alcohol is not bounded by any constant.

- *Appendix II*

Alcohol myopia and present bias

We could model alcohol myopia with the model of present bias used by O'Donoghue and Rabin (2003). Their utility function is given by the following equation:

$$U^t(u_t, u_{t+1}, ..., u_T) = u_t + \beta \sum_{\tau=t+1}^{T} \delta^{\tau-t} u_t$$

where u_t is the instantaneous utility of period t, δ is the standard discount factor and β represents the present bias (a preference for immediate gratification).

In order to represent alcohol myopia, we could assume that an individual that has consumed alcohol has a present bias that depends on the amount of alcohol that is accumulated in his/her blood. This term increases the discount of the future as the amount of alcohol in the blood increases. The extended inter-temporal utility function would be given by the following definition.

Definition 5: The perceived utility function for an individual that has alcohol myopia via the present bias is given by the following equation:

$$U^t(u_t, u_{t+1}, ..., u_T) = u_t + \beta(A^t) \sum_{\tau=t+1}^{T} \delta^{\tau-t} u_t$$

where A^t is the level of alcohol in the blood in period t and is given by $A^t = \sum_{i=t-w}^{t} a_i$,

where a_i is the amount of alcohol consumed in period i and w is the number of periods that the alcohol remains in the blood after its consumption. In order to represent that higher consumption of alcohol decreases the attention to the future, we assume that $\beta'(A^t) < 0$.

Alcohol myopia and exponential discounting

We could also represent alcohol myopia assuming that the consumption of alcohol affects the δ factor of the traditional exponential discounting utility function. In this case, the δ factor would be a decreasing function of the amount of alcohol that is accumulated in the blood. If the alcohol consumption affects the exponential discounting, then the outcomes of lotteries that are paid in the future will be discounted depending on how far they are in the future, as opposed to the case in which alcohol consumption affects the present bias, in which case all future payoffs are discounted equally, independently of how far in the future they are.

The following definition assumes that the exponential discounting is a function of the amount of alcohol that has accumulated in the blood.

Definition 6: The perceived utility function for an individual that has alcohol myopia via the exponential discounting is given by the following equation:

$$U^t(u_t, u_{t+1}, ..., u_T) = \sum_{\tau=t}^{T} \delta(A^t)^{\tau-t} u_t$$

where $\delta'(A^t) < 0$.

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