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ORIGINAL RESEARCH

Reward sensitivity and hazardous alcohol consumption in women: The parallel mediation effect of self-control and impulsivity traits

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ABSTRACT

Introduction: Little research has been carried out on the associations between several individual factors and hazardous alcohol use in women. The aim of this study was first, to study the relationship between reward sensitivity (RS) and alcohol use in both women with and without hazardous drinking separately. Second, to explore the potential mediating roles of the impulsivity and self-control traits in this relationship. *Method*: The study was analytical and cross-sectional and included 645 female participants (mean age = 19.14; standard deviation (SD)=1.60). All women were divided into two groups (286, 44.3%, with hazardous drinking, HDW; and 359, 55.7%, with light drinking, LDW). Correlation analyses were carried out to explore the associations between the variables, and parallel mediation analyses were performed to investigate the potential mediating roles of impulsivity and self-control in the RS-alcohol use associations in each group separately. *Results*: A significant association was observed between RS and alcohol use in HDW, contrary to that observed in their counterparts. In addition, both higher impulsivity and less self-control mediated the association between RS and alcohol use only in HDW. *Conclusions*: Impulsivity and self-control differently affect alcohol use under the condition of high reward sensitivity, only in HDW, suggesting alterations of the dual top-down and bottom-up mechanisms and a possible imbalance between the competing reflexive and impulsive brain systems. More research is needed regarding the individual factors that affect women's drinking to develop sensitive measures for the assessment of alcohol use and more efficient interventions for women.

KEYWORDS
Women; alcohol drinking; impulsive behavior; self-control

Introduction

In Europe, according to the World Health Organization (WHO), 58.4% of the total population of 20- to 24-year-olds are current drinkers, representing the highest prevalence of drinking peaks in the general population.[1] In Spain, 64.4% of 15- to 24-year-old men reported drinking at least one alcoholic beverage in the past month, compared to 54.8% for women in the same age range (EDADES, 2018). Despite the higher prevalence in men, most studies have disregarded the fact that current female drinkers are more vulnerable to alcohol-related consequences[2–4] and start to have alcohol-related problems sooner and drinking at lower rates than men.[3,5,6] This may be because females reach a similar degree of intoxication as males with a lower amount of alcohol due to their lower average body mass and the need for more time for alcohol metabolization.[7] Alcohol consequences are even more concerning in young adulthood, when consumption peaks in women and the differences between men and women are at the narrowest.[1] Despite these figures, little research has focused on the individual factors related to problematic alcohol use in women.

Impulsivity is a multifaceted construct that has been related to alcohol misuse, which is vastly supported by empirical studies.[8,9] More specifically, the scientific literature has proposed impulsivity and impaired self-control as crucial individual factors affecting alcohol behavior, especially in young adults.[10–12] Although both of them are extensively related, each component might contribute uniquely to alcohol use,[8,11,13] and their conjoint consideration has thus been recommended in studies exploring the ability to control alcohol use behavior.[14]

On the one hand, several measures of behavioral and self-reported impulsivity, representing bottom-up processes, have been shown to be predictors of alcohol use in several stages, from at-risk drinking to alcohol disorders.[12] However, there are no clear sex differences in this association,[15] and there is little evidence about how the impulsivity trait influences alcohol consumption specifically in college female students[16,17] or whether females who drink hazardously are more impulsive than those who drink lightly.[18] Conversely, self-control is a top-down process by which urges, desires, or behaviors are overridden. Thus, self-control is critical for regulating alcohol intake.[13] Several studies have found a relationship between

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self-control and alcohol use in young adults.[10,19,20] Likewise, and contrary to the impulsivity trait, further studies did point out an interesting sex difference in this process. While self-control is substantially disrupted in men due to acute alcohol doses,[21] the effects of frequent alcohol use over self-control are more detrimental for women.[15] Supporting this sex difference, Weafer et al.[5] showed that risky-drinking women presented lower inhibitory control due to alcohol use than men and non-risky drinking women, although they did not find any sex difference for impulsive behavior. Likewise, Nederkoorn et al.[15] showed that heavy-drinking women presented a more pronounced disinhibition response than men and other LDW. These results may suggest the relevant role of impaired or poorer self-control on women with problematic alcohol use but not on women with non-problematic alcohol use.

Another additional facet of impulsivity is the sensitivity to reward, which has been studied in terms of Gray's behavioral activation system (BAS) theory.[22] The BAS is a neurologically based system that guides behavior in response to reward signals via the dopamine system. This model proposes that individuals with a hypersensitive BAS may present exaggerated approach behaviors and a greater tendency to seek rewarding stimuli. Reward sensitivity (RS) has been extensively related to alcohol use in college drinkers[23,24] and more restrictively in women.[25] Previous studies suggested that RS drives positive affect, "impulsive state" and impulsive decision-making,[26,27] stimulating the strength of bottom-up processes under certain events/stimuli. Recent studies confirmed that men and women differ in self-control regulation and that their brain reward systems react differently to rewards, such as food, sex, and drugs.[28,29] Interestingly, young women present the highest presence of RS in their youth, in contrast to men,[30] leading to increased rewarding effects of alcohol in young female adults. Indeed, a previous study found that RS and impulsivity were able to predict hazardous drinking in young women.[25] Jauregi et al.[31] proposed that studying BAS-RS and impulsivity provides a better assessment of impulsivity than each dimension on its own. Additionally, RS has also been associated with self-control.[32,33] A recent study showed that non-dependent individuals with a risky drinking pattern showed a heightened RS, hindering their impulse control.[33] However, another study rejected the mediating role of self-control between RS and alcohol use in young adults.[20] These mixed results may be affected by the sex differences found in self-control[15,21] and on the peak age of alcohol consumption.[1] Indeed, age may be a crucial variable when studying the potential mediating role of impulsivity in the association between RS and alcohol use. The denominated developmental mismatch hypothesis proposes that brain structures stimulate impulsivity and are involved in reward and emotions (i.e., the nucleus accumbens and amygdala) have an earlier development than those that are related to self-control and planning (i.e., the dorsolateral prefrontal and dorsal anterior cingulate cortices). This mismatch may be responsible for higher impulsivity and, consequently, more risk-taking behaviors.[34,35] In posterior development, these connections are meant to change, leading to more effective control of prefrontal regions over the reward system at the end of adolescence.[36] However, in a longitudinal study, the authors found that the nucleus accumbens and the prefrontal cortex continue their development (with different patterns and rates) into the third decade of life.[37] Thus, young adults may still be vulnerable to factors affecting the development of brain function, such as hazardous alcohol consumption.[38,39] Interestingly, this vulnerability is also affected by sex, as young females with hazardous alcohol consumption show different brain development in prefrontal and striatal areas than healthy women and men.[40,41]

Despite all the literature above, most studies regarding the associations of these or similar variables were focused on the general population or only men,[12,13,20,42] and little research has focused on women. The main goals of this study were to first explore the relationship between RS and alcohol use in both women with and without hazardous drinking and, second, to study the potential mediating roles of the impulsivity and self-control traits in the association between sensitivity to reward and alcohol use in women with and without hazardous drinking separately. Due to the distinctive associations of each factor (self-control and impulsivity) with alcohol use and sensitivity to reward,[8,11,13,15] we opted for parallel mediation analysis. We hypothesized that the relationship between sensitivity to reward and alcohol use would be distinctly mediated by self-control and impulsivity. Based on the limited literature about these factors in women's alcohol behavior,[5,15,25] we further hypothesized that impaired control would show a greater mediating weight than impulsivity in the association between RS and HDW in women. To the best of our knowledge, this is the first study exploring the association of RS with alcohol use and the potential mediating roles of the self-control and impulsivity traits in young women who drink hazardously in comparison with those with a lighter pattern of alcohol consumption.

Materials and methods

Participants and procedure

We recruited a convenience sample of 1116 university undergraduate students; 80.1% were female, with a mean age of 20.17 years, and 19.9% were male, with a mean age of 20.45 years. We informed participants that we were conducting a research project about cognitive and personality variables and the patterns of alcohol use among university students. Participants were eligible if they agreed to participate in the study, were 25 years or younger, did not present any psychiatric, conduct, or neurological disorders (including developmental disorders, such as ADHD), and completed the questionnaire. For this study's purpose, we selected only women. After verifying the criteria, 645 university undergraduate female students met the criteria with a mean age of 19.14 years old ($SD = 1.60$) and a range between 18 and 25 years. The 55.65% ($n = 359$) were females who consumed lesser amounts of alcohol, and 44.34% ($n = 286$) drank hazardously. The battery of questionnaires was

applied in an online format through LimeSurvey hosted on the institutional server of a Spanish public universities. Participants were invited to participate in the study within the classroom and were provided with the necessary link to do so. Participation was voluntary and anonymous. It was emphasized that the questions should be answered truthfully while in a quiet place and during a single visit to the survey site. The project was carried out once it was approved by the Andalusian Biomedical Research Ethics Coordinating Committee and the Research Ethics Committee of Universidad Pablo de Olavide (Spain).

Measures

Hazardous drinking

A pretested and validated Spanish version of the Alcohol Use Disorders Identification Test (AUDIT[43]) questionnaire was used to assess the pattern of alcohol use.[44,45] The scale comprises 10 items referring to alcohol consumption and alcohol-related problems in the past 12 months. Each item scores between 0 and 4, except items 9 and 10, which only score 0, 2, and 4. Originally, the AUDIT was designed to measure three dimensions: consumption (items 1–3), dependence (items 4–6), and alcohol-related consequences (items 7–10). The cutoff point used for identifying HDW was 7.[44]

Impulsivity trait

A validated Spanish version of the Barratt Impulsiveness Scale (BIS-11) was used to assess the personality/behavioral construct of impulsiveness.[46,47] This self-report instrument comprises 30 items scored on a 4-point scale: rarely/never (0), occasionally (2), often (3), and almost always/always (4). It measures three first-order and six second-order factors of impulsiveness: attentional impulsiveness (attention and cognitive instability), motor impulsiveness (motor and perseverance), and non-planning impulsiveness (self-control and cognitive complexity).

Self-control

The Short Self-Regulation Questionnaire (SSRQ) is based on the Self-Regulation Questionnaire (SRQ[48]) that was designed to assess self-regulation capacity across the seven processes of self-regulation. A validated Spanish version of the SSRQ was used to measure the ability to regulate behavior to achieve one's goals.[49] The SSRQ questionnaire comprises 31 items scored on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) that can be summed to obtain a total score. It measures two-factor self-control and goal setting.

Reward sensitivity

A validated Spanish shortened version of the Sensitivity to Punishment and Sensitivity to Reward Questionnaire Version (SPSRQ–20[50]) was used to assess RS(RS). The SPSRQ-20 is a 20-item questionnaire on a 4-point scale, disagree (1), somewhat agree (2), quite agree (3), and totally agree (4), and includes two scales: Sensitivity to Punishment (BIS-SP) and Sensitivity to Reward (BAS-RS).

Statistical analysis

Statistical analyses were carried out using the Statistical Package for the Social Sciences (SPSS v25) through Macro Process v.3.5. Descriptive analyses (mean and standard deviation) and Pearson correlations for all variables were estimated. Analyses were split by the AUDIT total score into two groups: HDW (AUDIT $\geq$7) and LDW (non-problematic) (AUDIT $\leq$6). After that, a mediation analysis was applied. To estimate the mediating effects, model 4 with two parallel mediators[51,52] was applied with a 95% confidence interval (CI) and a bootstrapping of 10,000 iterations. To support the significant effect of the variables inside of the model, the lower levels for confidence intervals (LLCIs) and upper levels for confidence intervals (ULCIs) were included in the results. Regarding this study, RS was the independent variable, the AUDIT total score was the dependent variable and the self-control (M1) and BIS impulsivity (M2) traits acted as mediators. Other collected sociodemographic variables (such as the education of the parents and the family history of alcohol use problems or psychiatric disorders) were not considered as confounders because we found no evidence of association with the dependent variable (Table 1). Besides that, in our study, self-control and impulsivity are moderately correlated and this might lead to a problem of multicollinearity. However, the mediation model performed takes into account this condition. Hayes[51] states that the mediators are allowed to correlate, provided that they do not influence each other in causality. To avoid multicollinearity, we run a regression model in which the total AUDIT score was the dependent variable, and our two mediators (self-control and impulsivity) were entered as independent variables. The multicollinearity statistics showed a tolerance of 0.718 and FIV of 1.393, indicating no multicollinearity.

Results

Preliminary analyses

The study groups matched in age and education level. The clinical and sociodemographic characteristics of the sample are detailed in Table 1. HDW showed higher AUDIT scores, higher impulsivity (total BIS-11 score), higher sensitivity to reward, and lower self-control than LDW. In addition, correlational analyses were conducted among the variables, before testing our mediational hypotheses, in each group separately (see Table 2).

Parallel mediation

The results obtained for HDW are depicted in Figure 1. The results for LDW are not depicted, as there was no significant indirect effect in the parallel mediation analysis. In relation

Table 1. Demographic and Clinical Characteristics of the Groups.

	Hazardous drinking women $N = 286$ Mean (*SD*)	Light drinking women $N = 359$ Mean (*SD*)	Statistics*	*p*-Value
Age	19.13 (1.51)	19.16 (1.67)	0.184	0.854
University education	1.15 (0.82)	1.05 (0.94)	−1.431	0.153
Family history of AUD	41 (14.34%)	34 (9.47%)	3.666	0.064
Family history of PD	29 (10.14%)	48 (13.37%)	1.580	0.223
Education of the mother			2.818	0.421
No studies	2 (0.7%)	8 (2.23%)		
Primary studies	46 (16.08%)	51 (14.21%)		
Secondary studies	128 (44.76%)	164 (45.68%)		
University	110 (38.46%)	136 (37.88%)		
Education of the father			7.152	0.067
No studies	1 (0.35%)	11 (3.06%)		
Primary studies	58 (20.28%)	80 (22.28%)		
Secondary studies	141 (49.30%)	163 (45.40%)		
University	86 (30.07%)	105 (29.25%)		
Body mass index (BMI)	21.82 (3.35)	21.81 (3.31)	0.015	0.988
Self-control	38.46 (6.34)	41.50 (6.41)	6.028	0.000
BIS impulsivity	48.93 (12.56)	42.72 (12.22)	−6.330	0.000
Reward sensitivity	18.61 (4.83)	17.48 (4.6)	−2.986	0.003
AUDIT	8.23 (3.16)	2.28 (1.32)	−29.833	0.000

Note. All these variables represent self-reported measures.
AUD: alcohol use disorders; PD: psychiatric disorders; BIS: Barratt Impulsiveness Scale; AUDIT: Alcohol Use Disorders Identification Test.
*Statistics: *t*-Student for all variables except for family history of AUD/PD and Education of the mother/father where X^2 are shown. University education refers to the actual years spent in university education. Education of the mother/father is measured by the level of education achieved.

Table 2. Correlation matrix with data for hazardous drinking and light drinking women separately.

	Hazardous drinking			Light drinking		
	1	2	3	1	2	3
1. AUDIT						
2. Reward sensitivity	0.159**			−0.007		
3. Self-control	−0.311**	−0.241**		−0.116*	−0.204**	
4. BIS impulsivity	0.286**	0.153**	−0.531**	0.135*	0.205**	−0.524**

BIS: Barratt Impulsiveness Scale; AUDIT: Alcohol Use Disorders Identification Test.
Note. **Correlation is significant at $p < 0.01$ (bilateral). *Correlation is significant at $p < 0.05$ (bilateral).

to the HDW group, the total effect ($c = 0.104$, SE = 0.049, $t = 2.142$, 95% CI = 0.008, 0.199) of RS on AUDIT was significant. Conversely, the direct effect of this relationship was not significant (path c′; $c = 0.055$, SE = 0.046, $t = 1.197$, 95% CI = −0.036; 0.146). In other words, the direct effect of RS on alcohol use was negligible despite its positive relationship. Regarding the indirect effects, the first path represents the mediating effect of self-control (M1) in the relationship RS-AU (namely, RS→SC→AU). This path (a1b1) showed a significant effect ($c = 0.032$, 95% CI = 0.009, 0.063). As the confidence interval did not include zero, these results supported the mediating effect of SC. In other words, those with more RS demonstrate more alcohol use when they present lower self-control. The second indirect path, representing the mediating effect of the BIS-11 impulsivity trait (namely, the path RS→BIS-11→AU), also showed a significant effect ($c = 0.017$, 95% CI = 0.002, 0.036). Accordingly, those with higher RS demonstrate more BIS impulsivity, which leads to more alcohol use.

After testing the potential influence of our sociodemographic variables over the mediation model, the results

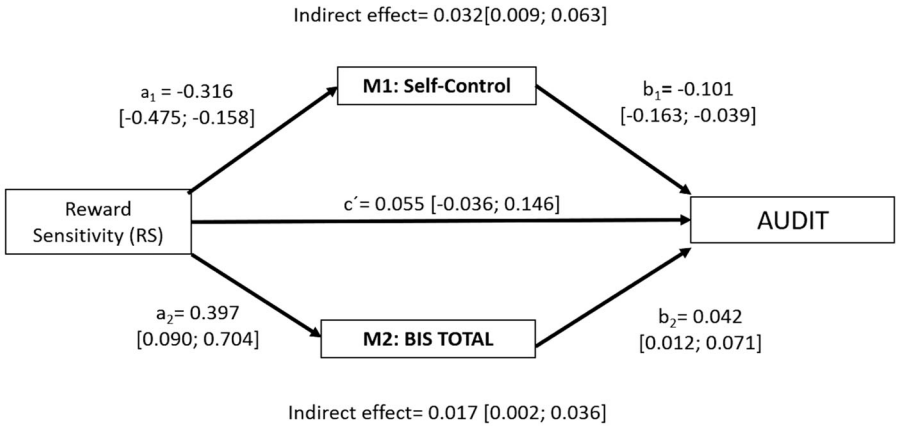

Figure 1. Parallel mediation analysis conducted in PROCESS v3.5 with reward sensitivity as independent predictor, AUDIT as dependent variable and self-control (M1) and BIS impulsivity (M2) as mediators on hazardous drinking women. *Note.* This mediation model corresponds to the 4th model in Preacher and Hayes.[76] Both Beta coefficient values and 95% confident intervals are shown for each path. *Abbreviations*: BIS: Barratt Impulsiveness Scale; AUDIT: Alcohol Use Disorders Identification Test.

remained in the same direction. In the HDW group, the direct effect between reward sensitivity and the total AUDIT score disappeared, as in our present results, when the mediators were included (95% CI: −0.0394, 0.1395). The indirect effect of impulsivity (0.0016, 0.0339) and self-control (0.0113, 0.0656) remained. In the LDW, no mediator resulted significantly (see Supplementary Material).

Discussion

This study aimed to analyze the association between RS and alcohol use in women with and without hazardous drinking separately and to explore the mediating roles of both the impulsivity and self-control traits in this relationship.

As expected, RS significantly predicted alcohol use in women with hazardous alcohol use. This is not surprising, as women reach their peak of alcohol consumption in young adulthood (18–25 years old[1]) as happens with the sensitivity to rewards, which is more present in the early twenties than in other life periods in women.[30] This is especially important, as changes in personality relate to changes in problematic alcohol involvement.[53] Thus, even if higher RS is related to heightened rewarding effects of alcohol in male and female heavy drinkers,[54] in young women, alcohol might have the highest stimulating and rewarding effects in all developmental stages, and this pleasurable effect might increase the drive for excessive drinking despite the consequences.

Despite these results, the direct effect of sensitivity to reward over alcohol consumption disappeared when the mediating variables were entered. Our results showed that low self-control mediated the relationship between RS and alcohol use in HDW but not in LDW. This significant indirect pathway showed an alteration in the top-down process, and it is supported by some studies showing a relevant association between cognitive control ability and alcohol use[55] and with sensitivity to reward[25] in women. Regarding our measure of self-control, the questionnaire used was a general measure of control over several stimuli and not only alcohol.[56] This could lead to general disinhibition in the behavior of HDW, exacerbated by the higher RS. In this sense, these individuals might have difficulties related to proactive self-control.

Our second indirect path refers to the bottom-up processes, namely, the mediating role of the impulsivity trait, as measured by the BIS-11, in the association of sensitivity to reward with alcohol use. There is a well-established association between the impulsivity trait and alcohol use in drinking college students.[57,58] However, this is the first time that higher RS was shown to lead to more alcohol use in the condition of higher impulsivity in HDW but not in LDW. Previous investigations showed a direct association between these measures,[26,59] concluding that higher sensitivity to reward led to an "impulsive state"[26] and to interindividual variations in impulsivity.[59] In fact, sensitivity to reward is strongly associated with external influences,[60] and this biological activating system underlying sensitivity to reward may be a "driver" of enhanced impulsiveness under the external availability of alcohol.

Previous research has also shown that young adults with higher use of alcohol present more recruitment of cognitive control prefrontal areas while trying to inhibit alcohol cues[9] and higher activation of the brain reward system.[61] There are studies showing relevant variations in the prefrontal cortex in men and women referred to as gray and white matter.[62–65] This can contribute to explaining difficulties in self-control and differences between men and women in this ability. In turn, an alteration between reflexive and impulsive brain areas could be implicated in heavy alcohol use not only in adolescents but also in young adults.[9,37] There is insufficient research showing alterations in the reward systems of people who drink in excess and differences in how alcohol affects men and women. First, alcohol consumption is basically a social activity, and the reward system in women is more sensitive to prosocial rewards than in men.[66] Men who drink alcohol heavily have a smaller brain reward network than those who do not drink alcohol, but there is little information concerning women's brains.[67] Recent research, however, has found that the opposite occurs; in women, the reward network in the brains of those with alcohol addiction is larger than that of non-drinkers.[64] This could mean a developmental alteration in the women's reward system induced by alcohol abuse.

Impulsivity occurs when responding produces immediate, relatively smaller, reinforcers at the expense of delayed larger reinforcers while self-control occurs in the opposite direction, thus, both traits respond to reward.[68] After a certain reward is presented, both operate simultaneously and, when dysregulated, interact with each other to accentuate risky behaviors.[69–71] In this sense, women with lower self-control might have more difficulty suppressing inappropriate behaviors,[15] and this combined with higher impulsivity would lead to increased alcohol use, in contrast to women who drink less and have better self-control and less impulsivity.

Importantly, in this study impulsivity and self-control were measured separately. This is interesting for several reasons. Previous studies have shown that impulsivity and self-control might have a sex-dependent link with alcohol use, which makes it plausible to explore a separate potential influence over problematic alcohol use. However, as stated in the hypotheses section, the studies aforementioned showed inconclusive results about the separate association of our mediators and alcohol use in women, and we wanted to explore that direction.[5,15,21,25] Besides, López-Caneda et al.[14] emphasize the relevance of exploring both constructs separately in the studies examining alcohol use, and Leeman et al.[11] highlights the unique contribution of impulsivity and self-control in the explanation of alcohol use. In addition to the aforementioned, decision-making in risky behaviors depends on the dual system based on both impulsivity and self-control.[14,72] Most of the studies on alcohol use focus on the functioning of the reflective system (self-control) while less attention is paid to the automatic affective system (impulsivity) or the interaction between the two.[73] However, both are necessarily included in the theoretical models

explaining problematic alcohol use in the young population.[72] In our study, we have followed the main theoretical models and recommendations to achieve a broader view of alcohol consumption in women.

These results should be considered in the context of several limitations. First, we have studied the unidirectional relationship between impulsive measures and alcohol consumption, and many studies have remarked on the vicious cycle created between both types of measures.[74] However, our cross-sectional design did not allow us to perform the appropriate testing for such a purpose. In this sense, with our current approach, it was not possible to determine which traits are more implicated in alcohol use or whether both impulsivity and self-control have distinct relationships with different alcohol behavior indexes.

This study shows that women have a special vulnerability and specific individual factors that affect their alcohol use. Specifically, college women with problematic alcohol use showed alterations in top-down (low self-control) and bottom-up (high impulsivity) processes regarding their control over alcohol consumption. This altered dual system may lead not only to alcohol misuse in their college ages. Regarding the special vulnerability of women to alcohol, this dysregulation may lead to even more serious consequences, such as alcohol-related disorders or other neuropsychological or neural alcohol-related alterations.

Hazardous alcohol use has been traditionally investigated as a male-oriented issue. Thus, interventions have been created regarding scientific support mainly focused on men. However, gender-based roles are changing, and women drink more.[6] Due to this situation, much more research is needed to properly develop interventions and prevention programmes based on the individual vulnerabilities and necessities of women. Additionally, more research about this matter may lead to improvements in the sensitivities of measures assessing alcohol use and alcohol-related problems in women.

Implications for practice

Our study shows that RS significantly predicted alcohol use in women with hazardous alcohol use but not in LDW. Alcohol might produce a stimulating and rewarding effect on this developmental stage, and this pleasurable effect might increase the drive for excessive drinking despite the consequences. This result highlights the relevance of addressing personality indexes related to problematic alcohol in interventions for reducing alcohol use at this age. Likewise, our data show the importance of working on proactive self-control related to increased alcohol consumption and the need to work on possible alterations of the reward system induced by alcohol abuse in women. In this sense, the approach of attentional bias modification has shown moderate but positive effects in the reduction of the motivational value of alcohol cues.[75] Accordingly, carrying out interventions that address these aspects in women in this age range could prevent the abusive consumption of alcohol and its negative consequences.

Conclusion

Our results show that impulsivity and self-control affect alcohol use in parallel under the condition of high reward to sensitivity only in women who drink hazardously, suggesting alterations in the dual top-down and bottom-up mechanisms and a possible imbalance between the competing reflexive and impulsive brain systems.

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Author contributions

CMP, EVM, JJFM, JMGG, and LMGM specifically developed the design and methods for this study. CMP, JJFM, and JMGG conducted statistical analyses. CMP, EVM, and LMGM contributed to the interpretation of the data. All the authors developed the first draft and contributed to improve and approve the final manuscript.

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