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## Trajectories of impulsivity by sex predict substance use and heavy drinking

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## HIGHLIGHTS

- Two trajectories of impulsivity were found in males and five were found in females.
- The increasing trajectory in males predicted being a smoker and a heavy drinker.
- The early increasing trajectory in females was the most risky class.
- High lack of premeditation and delay discounting were the highest-risk facets.

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## ABSTRACT

Although impulsivity and sensation seeking have been consistently associated with substance use, few studies have analyzed the relationship between changes in these variables and substance use in early adolescents. The aim of this study was to identify trajectories of impulsivity and sensation seeking and explore their relationship with substance use and heavy drinking. A total of 1342 non-user adolescents (53.6% males; mean age = 12.98,  $SD = 0.50$ ) annually completed the Barratt Impulsiveness Scale, the Zuckerman's Impulsive Sensation Seeking scale and a delay discounting task, over a total period of three years. Past alcohol, tobacco and cannabis use, drunkenness episodes (DE) and problem drinking were also assessed. Impulsivity trajectories were explored using latent class mixed modelling. To study their predictive power binary logistic regressions were used. Two trajectories of impulsivity were found in males and five were found in females. Males with an increasing impulsivity trajectory were more likely to report tobacco [odds ratio (OR) = 1.84] and cannabis (OR = 3.01) use, DE (OR = 2.44) and problem drinking (OR = 3.12). The early increasing trajectory in females predicted tobacco use (OR = 3.71), cannabis use (OR = 5.87) and DE (OR = 3.64). Lack of premeditation and delay discounting were the most relevant facets in high-risk trajectories. Selective intervention and more intense and tailored treatment might help these adolescents to reduce early increases in impulsivity and prevent escalation of substance use.

## 1. Introduction

Impulsivity and sensation seeking (SS) have been widely associated with the early use of different substances (Jentsch et al., 2014; Mitchell & Potenza, 2014), representing an important risk factor for developing substance-related problems and substance use disorders later in life (Moss, Chen, & Yi, 2014). While impulsivity can be defined as a predisposition toward rapid reactions to different classes of stimuli without regard to potential negative consequences (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001), SS refers to the seeking of experiences regardless of their associated risk (Zuckerman, 1994).

Numerous studies have consistently reported developmental changes in these two personality traits (Collado, Felton, MacPherson, & Lejuez, 2014; Littlefield, Stevens, Ellingson, King, & Jackson, 2016; Steinberg et al., 2008). As suggested by the dual systems model (Shulman et al., 2016), SS tends to peak at mid-adolescence (i.e. ages 14–17) decreasing thereafter, while impulsivity shows a linear decrease from early (ages 10–13) to late (ages 18–21) adolescence. Notwithstanding this, deviations in the aforementioned general development have also been reported (Collado et al., 2014; Harden & Tucker-Drob, 2011; Pedersen, Molina, Belendiuk, & Donovan, 2012). The number of studies exploring these divergences and the consistent evidence of

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gender differences in some facets (Cross, Copping, & Campbell, 2011) contrast with the paucity of studies examining gender-related differences in developmental changes in impulsivity (Collado et al., 2014; Littlefield et al., 2016). Although most studies in drug research have focused on the association between different levels of impulsivity and substance use (Mitchell & Potenza, 2014), it is possible that clinically relevant substance use is only related to certain patterns of impulsivity development (Sher, Gotham, & Watson, 2004), and that these patterns may differ by sex. Consequently, identifying high-risk patterns may enhance personality-targeted preventive intervention for substance use and escalation (Conrod, Castellanos-Ryan, & Strang, 2010).

One valuable approach to explore longitudinal variations in impulsivity between individuals is latent class growth modelling. Using this analytic approach, subpopulations with different levels and patterns of change in impulsivity can be identified. Once these subgroups are delimited, it is possible to describe their characteristics in relation to changes in specific facets of impulsivity and to explore their relationship with clinically relevant outcomes. Previous studies have reported between two and four trajectories of impulsivity and SS (Liu et al., 2013; Lynne-Landsman, Graber, Nichols, & Botvin, 2011; White et al., 2011). Although these studies differ regarding participants' ages and sex, variables assessed and length of time between follow-ups, participants with higher impulsivity trajectories reported more substance use, heavy drinking and gambling problems than those in the lower trajectories (Liu et al., 2013; Lynne-Landsman et al., 2011). Moderate trajectories tended to vary along with changes in the patterns of substance use (Lynne-Landsman et al., 2011; White et al., 2011).

Several shortcomings regarding the background of the samples and the assessments of impulsivity and substance use limit the impact of the findings. These studies used convenience samples of adolescents from minority populations and two of them included only male participants (Liu et al., 2013; White et al., 2011). Impulsivity was assessed using either observational information (Liu et al., 2013; White et al., 2011) or isolated items rather than validated instruments (Lynne-Landsman et al., 2011). Finally, substance use was poorly evaluated using composite scores (Lynne-Landsman et al., 2011) or collecting data on the quantity but not frequency of alcohol use (White et al., 2011). The present study aims to overcome gaps in the literature by identifying trajectories of impulsivity among early adolescents of both sexes from the general population and analyzing their relationship with the use of different substances, and heavy drinking. Using a comprehensive assessment approach, several facets of impulsivity were assessed (four self-reported and one behavioral measure). The specific objectives were: 1) to identify developmental trajectories of impulsivity; and 2) to explore the predictive power of these trajectories on alcohol, tobacco and cannabis use, episodes of drunkenness and alcohol-related problems. Considering the abovementioned gender differences, we hypothesized the existence of different trajectories by sex. No a priori hypotheses were established regarding the nature of such trajectories or their association with the use of different substances.

## 2. Materials and methods

### 2.1. Participants

A total of 1790 adolescents from 22 randomly selected Spanish high schools were assessed. The exclusion criteria were: 1) being over 15 years old at T1; 2) having any sensory impairment; 3) having any intellectual disability; and 4) presenting random responses. Some studies have reported altered levels of impulsivity among participants who persistently use alcohol and other drugs (Acheson et al., 2016; Peeters, Vollebergh, Wiers, & Field, 2014). Indeed, one of the most important limitations of studies exploring the relationship between impulsivity and substance use is the influence of past substance use in the current and prospective levels of impulsivity (Mitchell & Potenza, 2014). To remove any influence of previous substance use in impulsivity and SS,

participants that reported having used any drug three or more times within the last year at the baseline were removed. After excluding 448 participants (56 due to age, 4 for intellectual disability, 118 for random responses and 270 for substance use), the final sample included 1342 participants (74.97%). In order to obtain the parents' written consent, letters were mailed giving guarantees of confidentiality and anonymity. No parents refused permission. The Ethics Committee of the Secretary of State of Research and Innovation, the local educational authorities and the participating schools approved this study.

### 2.2. Measures

*Demographical data* regarding participants' age and sex were collected. In order to detect random responses, the Oviedo Infrequency Scale (INF-OV; Fonseca-Pedrero et al., 2009) was used. Its 12 Likert-type items were interspersed throughout the assessment and participants with more than three wrong answers were excluded, following the authors' guidelines.

A Spanish adaptation of the *Barratt Impulsiveness Scale* for adolescents (BIS-11-A; Martinez-Loredo, Fernandez-Hermida, Fernandez-Artamendi, Carballo, & Garcia-Rodriguez, 2015) was used to assess impulsivity. The BIS-11-A includes 30 Likert-type items (from rarely or never to almost always or always). Consistently with previous studies among adolescents (Leshem & Glicksohn, 2007; Yao et al., 2007), the BIS-11-A comprises two subscales with good reliability: general (BIS-g,  $\alpha = 0.79–0.81$ ) and non-planning (BIS-np,  $\alpha = 0.73–0.74$ ) impulsivity.

An adaptation of the *Impulsive Sensation Seeking scale* (ImpSS; Fernandez-Artamendi, Martinez-Loredo, Fernandez-Hermida, & Carballo, 2016) was also used. The ImpSS has 19 true/false items and provides two scores: Impulsivity (Imp,  $\alpha = 0.75–0.76$ ), primarily covering lack of premeditation (Zuckerman, Kuhlman, Joireman, Teta, & Kraft, 1993), and Sensation Seeking (SS,  $\alpha = 0.74–0.76$ ).

A *delay discounting task* (DD) was used to assess impulsive choice. DD describes how a reinforcer loses value as the delay to its receipt increases. Using an adjusting-amounts procedure (Holt, Green, & Myerson, 2012), participants have to choose between a virtual amount of 1000 euros available after seven different delays (one day, one week, one month, six months, one year, five years and twenty-five years) versus multiple amounts of money available immediately. This DD task has been extensively used in drug research (Amlung, Vedelago, Acker, Balodis, & MacKillop, 2017) and its psychometric properties when used among early adolescents were good (Martinez-Loredo, Fernandez-Hermida, Carballo, & Fernandez-Artamendi, 2017). Based on participants' responses, seven indifferent points were identified and fitted to the Mazur equation (Mazur, 1987):

$$V = \frac{A}{1 + kD}$$

This equation describes the discount in the subjective value ( $V$ ) of the magnitude of a given reinforcer ( $A$ ) as a function of the time in days ( $D$ ) to its delivery.  $K$  represents the rate of discounting. Due to the skew in the distribution of  $k$ -values, analyses were performed using the log-transformed  $k$ -values ( $\log k$ ; Mazur, 1987).

*Substance use* was analyzed using items from the European School Survey on Alcohol and other Drugs (ESPAD; European School Survey Project on Alcohol and Other Drugs, 2007) regarding the frequency of past year alcohol, tobacco and cannabis use (none, 1–2 times, 3–5 times, 6–9 times, 10–19 times, 20–39 times), and past month drunkenness episodes (DE). Problem drinking was assessed by means of the Spanish adaptation (López-Nuñez et al., 2012) of the Rutgers Alcohol Problem Index (RAPI; White & Labouvie, 1989). The proposed cut-off of seven points for problem drinking and possible dependence yielded adequate levels of sensitivity (81.2%) and specificity (72.2%). Age at first drink (AFD) was also collected. For analysis purposes, we dichotomized self-reported frequency of substance use and DE (no = 0, yes = 1).

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