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Psychometric properties of CAST for early detection of problematic cannabis use in Spanish adolescents

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ABSTRACT

The high prevalence rates of cannabis use in adolescents and its early onset constitutes a major public health problem, raising the need for its early detection. The availability of validated tools to analyze early cannabis use is essential to detect problematic use at an early age. The Cannabis Abuse Screening Test (CAST) (Legleye et al., 2007) is widely applied in Europe; however, the CAST cut-off scores vary according to the setting, the screening objective, and the correction version (CAST-f or CAST-b), creating therefore confusion in its application. Moreover, the psychometric properties of the CAST as a tool for detecting problematic cannabis use are understudied. To fill this gap, such psychometric properties have been analyzed in a sample of Spanish adolescents while using different cut-off scores for CAST-f and CAST-b. Based on our findings, the optimal cut-off scores are 2 points for CAST-b and 4 points for CAST-f. The internal reliability of CAST-f ($\alpha = 0.83$) and CAST-b (KR-20 = 0.80) are satisfactory. Factorial analysis suggested the assumption of a one-dimension model. The CAST seems to be a valid and reliable tool for early screening of problematic cannabis use in Spanish adolescents.

1. Introduction

Cannabis continues to be the most used illegal substance by the general population in Europe (European Monitoring Centre for Drugs and Drug Addiction [EMCDDA], 2020a). According to the European School Survey Project on Alcohol and Other Drugs (ESPAD) Report 2019, 16% of European students between the ages of 15 and 16 reported having ever used cannabis (EMCDDA, 2020a). The highest prevalence of cannabis use in Europe was observed in Czech Republic (28%), Italy (27%), Latvia (26%) and Spain (23%) (EMCDDA, 2020a).

Beyond the alarming high prevalence rates of cannabis consumption, it is crucial to tackle other persisting related parameters: the impact of synthetic cannabinoids (Karila, Benyamina, Blecha, Cottencin, & Billieux, 2016), new consumption formats such as the use of hookahs, "dabbing", "cannavaping" or vaporizers (Papaseit et al., 2018), and the variation of tetrahydrocannabinol (THC) levels (Chandra et al., 2019), which has led to the production and consumption of powerful products, with high THC concentration (Meier, Docherty, Leischow, Grimm, & Pardini, 2019), as well as to the commercialization of products with low THC content by herbalists (EMCDDA, 2020b).

Experts have also alerted about the upward trend of youth cannabis consumption. For instance, in Spain, 222,000 students initiated cannabis use in 2018, with higher frequency among girls than boys (Spanish Observatory on Drugs and Addictions, & Government Delegation for the Spanish National Drugs Plan, 2020). In 2020, the prevalence of Spanish students in the age range between 14 and 18 who declared ever using cannabis reached 33% (Spanish Observatory on Drugs and Addictions, & Government Delegation for the Spanish

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National Drugs Plan, 2020).

The early onset of cannabis use continues to be a major concern. Since 2000, the age of initiation of cannabis use in Spain has been under 15 years (Rial et al., 2019; Spanish Observatory on Drugs and Addictions, & Government Delegation for the Spanish National Drugs Plan, 2020). In comparison with late-onset cannabis use, early use is associated with greater health consequences (Bechtold, Simpson, White, & Pardini, 2015; Di Forti et al., 2019; Feingold, Weiser, Rehm, & Lev-Ran, 2016; Fonseca-Pedrero, Lucas-Molina, Pérez-Albéniz, Inchausti, & Ortuño-Sierra, 2020), higher risk of dependency on the drug, poorer academic or work performance, and higher probability of developing a risky pattern of alcohol consumption or binge drinking, and/or polysubstance use (Míguez-Varela & Becoña, 2015; Volkow et al., 2016).

According to ESPAD Report 2019, 4% of the European students can be classified as high-risk cannabis users (EMCDDA, 2020b), although this prevalence varies greatly within the different European countries, with the lowest and highest prevalence registered in Macedonia (1.4%) and France (7.3%), respectively. The *EU Agenda and Action Plan on Drugs 2021–2025* (European Commission, 2020) insists on prioritizing detection and prevention of drug use by adolescents. Therefore, the availability of validated screening instruments adapted to the adolescent population in each country is of the utmost importance.

The Cannabis Abuse Screening Test (CAST) (Legleye et al., 2007) is the most applied screening tool in Europe. It encompasses 6 items that are answered using a five-point Likert scale. Two correction versions of the CAST are available in the literature: the full version (CAST-f) in which 0 to 4 points are attributed to each item to form a final maximum score of 24 points; and a binary version (CAST-b) in which a score of 0 or 1 point is assigned to each item, and the final score of the test ranges between zero and six points. In CAST-b the threshold for positive responses varies between questions, such as "sometimes" for some questions, and "rarely" for others (Legleye et al., 2007).

Several studies have evaluated the psychometric properties of the CAST for its application in the adolescent population (as shown in Table 1 those studies were generally carried out in European countries such as France, Spain, Italy, and Hungary. Except for the study undertaken in France, where the CAST was validated for the screening of problematic cannabis consumption using the *Problem Oriented Screening Instrument for Teenagers* (POSIT) as a gold standard (Legleye et al., 2007), most studies have performed the validation of the CAST to detect Cannabis Dependence (CD) or Cannabis Use Disorder (CUD) using the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) as a gold standard (Bastiani et al., 2013; Cuenca-Royo et al., 2012; Fernandez-Artamendi, Fernández-Hermida, Muñiz-Fernández, Secades-Villa, & García-Fernández, 2012; Gyepesi et al., 2014; Legleye, Kraus, Piontek, Phan, & Jouanne, 2012; Legleye, Piontek, & Kraus, 2011; Legleye, Piontek, Kraus, Morand & Falissard, 2013).

A problem pending to be solved among the researchers in this field is the lack of agreement on the terminology used to describe the problem of cannabis use. Some authors choose to use *risky use* (Seidel, Morgenstern, & Hanewinkel, 2020), *problematic use* (Spanish Observatory on Drugs and Addictions, & Government Delegation for the Spanish National Drugs Plan, 2020), or *hazardous use* (Wong et al., 2019), while others opt for *cannabis abuse* (Legleye et al., 2013), *cannabis use disorder* (Gyepesi et al., 2014), or *cannabis dependence* (Bastiani et al., 2013). In this regard, the original authors of the CAST developed this tool "to screen for harmful cannabis use" (Legleye et al., 2007, p. 235), taking the term used by the World Health Organization in the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10), defined as "a pattern of cannabis use that is causing damage to health. The damage may be physical or mental" (World Health Organization. (2008), 2008, p. 290). Nevertheless, in the same paper, the authors also described the CAST as "an efficient tool in order to screen for cannabis use disorders among adolescents and young adults" (Legleye et al., 2007, p. 233), and then they emphasized the need for a "screening and assessment of harmful drug consumption in this population group, by defining three risk levels for the CAST, which specifically deals with problematic cannabis use" (Legleye et al., 2007, p. 241). Experts have warned about terminological differences in this area on several occasions, as described in the systematic review by Casajuana et al. (2016). The authors state that "while cannabis dependence has been widely studied, previous cannabis use states remain imprecisely described" (Casajuana et al., 2016, p. 8) and insist that "working on official definitions is highly necessary, as the criteria used remain incomplete, leading to increased confusion in the field" (Casajuana et al., 2016, p. 1). Taking into consideration this confusing conceptual framework and being aware of the problem arising from cannabis use at early ages, this study adopts the term *problematic cannabis use*, following the working definition proposed by the EMCDDA: "Problematic use can be defined as use leading to negative consequences on a social or health level, both for the individual user and for the larger community" (Beck & Legleye, 2008, p. 31). Notice that this coincides with the prevalence concept estimated in national and international adolescent population surveys when using the CAST, such as the Spanish State Survey on the Use of Drugs in Secondary Schools (ESTUDES) or the French Survey on Health and Use on National Defence and Citizenship Day (ESCAPAD).

Another issue is the fact that the proposed CAST cut-off score varies depending on the version (CAST-b or CAST-f), the age range of the sample, and the country, thus leading to some confusion in the interpretation of the CAST results. For instance, in Spain, the ESTUDES applied a cut-off score of 4 points for CAST-b (Spanish Observatory on Drugs and Addictions, & Government Delegation for the Spanish National Drugs Plan, 2020), as it was suggested by Cuenca-Royo et al. (2012). According to the latest report of ESTUDES in 2019, a quarter of the Spanish adolescents who had used cannabis in the prior year could be considered problematic cannabis users. However, the ESPAD survey, which also applied CAST-b but used a cut-off score of 2 points (EMCDDA, 2020b), reported a higher prevalence (35%) of problematic cannabis users in Europe in that same year. This variation in the estimated prevalence could be due to a difference in the expansion of cannabis use across countries or due to the application of different correction systems of the CAST as warned by ESPAD in their statement "*it is clear that different computation methods would produce different results. It is widely recognized that further research is needed to reach a common agreement on the best computation method for the CAST for different target populations*" (EMCDDA, 2020b, p. 112). Furthermore, any applied cut-off score should be validated in each setting and according to the purpose of the screening (e. g. detection of problematic cannabis use, cannabis abuse disorder or dependence on cannabis). On the other hand, inconsistencies also exist regarding the dimensionality of the CAST; while most studies indicated a one-dimensional structure of the tool (Bastiani et al., 2013; Fernandez-Artamendi et al., 2012; Gyepesi et al., 2014), other researchers (Legleye, 2018; Legleye et al., 2015) have suggested a bidimensional structure.

Considering the early-onset cannabis use, it is important to implement early detection programs, and hence the availability of validated screening tools for problematic use is crucial (García-Couceiro et al., 2021).

The CAST is understudied in the context of problematic cannabis use. Therefore, this study aims to analyze the psychometric properties of the CAST as a tool for the early detection of problematic cannabis use in Spanish adolescents. The two correction versions of the CAST (CAST-f and CAST-b) have also been compared in order to provide evidence of the most suitable format and cut-off score for the screening of problematic cannabis use.

2. Methods

2.1. Study population

To address these issues, a cross-sectional study was conducted. For

Table 1
Psychometric properties of CAST for adolescents reported in scientific literature.

Authors	Year	Country	n	Screening objective	Gold Standard	CAST Version	Cut-off scores	Cronbachs α	Sensitivity	Specificity	AUC
Legleye et al.	2007	France	1728 (14–22 years old)	Problematic Use	POSIT	Binary	4	0.81	0.93	0.81	0.92
Legleye et al.	2011	France	2566 (17 years old)	Cannabis dependence (CD) and Cannabis use disorder (CUD)	DSM IV criteria	Binary	2 (same for CD and CUD)	0.74	CD: 0.77 CUD: 0.70	CD: 0.79 CUD: 0.87	CD: 0.84 (CI95%: 0.83–0.86) CUD: 0.85 (CI95%: 0.84–0.87)
						Full	3–4 (same for CD and CUD)	0.77	CD: 0.84 (3); 0.76 (4) CUD: 0.79 (3); 0.71 (4)	CD: 0.71 (3); 0.78 (4) CUD: 0.80 (3); 0.87 (4)	
Legleye et al.	2012	France	140 (15–26 years old) [clinical simple users seeking treatment]	Cannabis Use Disorders (CUD)	Adolescent Diagnostic Interview-Light (ADI-Light) DSM-IV	Binary	3	0.66	0.92	0.66	0.87
						Full	6	0.73	0.93	0.66	0.86
Fernandez-Artamendi et al.	2012	Spain	144 (16–20 years old)	Cannabis dependence (CD)	DSM IV-TR criteria	Full [scale with five response options 1: never to 5: very often]	5	0.84	0.83	87	0.92 (CI95%: 0.88-0.96)
Cuenca-Royo et al.	2012	Spain	241 (18–25 years old)	Substance Use Disorders (SUD) and Dependence	The Psychiatric Interview for Substance and Mental Disorders (PRISM)-DSM-IV	Binary	SUD: 4	0.74	0.81	0.57	0.75
							Dependence: 4	0.75	0.89	0.49	0.74
						Full	SUD: 9	0.79	0.74	0.69	0.79
							Dependence: 12	0.79	0.57	0.84	0.79
Legleye et al.	2013	France	3266 (17–19 years old)	Latent classes of cannabis use (DSM-IV)	Latent class structure of the DSM-IV	Full	Severe Class: 7 Moderate Class: 3	No information	0.88 0.77	0.84 0.80	0.92 0.85
Bastiani et al.	2013	Italy	5787 (15–19 years old)	Cannabis dependence (CD)	Munich composite International Diagnostic Interview (DSM-IV)	Binary	3	0.78	0.78	0.82	0.88
						Full	6		0.80	0.80	0.87
						MCA [new version of the scale made by the authors]	7		0.80	0.81	0.87
Gyepesi et al.	2014	Hungary	467 high school students (mean age = 16.41) and 439 college students (mean age = 23.9)	Cannabis dependence (CD) and Cannabis use disorder (CUD)	Munich composite International Diagnostic Interview (DSM-IV)	Binary	High school: 2	High school = 0.76	CD = 0.86 CUD = 0.62	CD = 0.95 CUD = 0.97	CD = 0.95 CUD = 0.95
							College school: 2	College school = 0.71	CD = 0.78 CUD = 0.68	CD = 0.94 CUD = 0.97	CD = 0.93 CUD = 0.89

this purpose, a survey on substance use was carried out in a sample of students recruited from 12 schools in Galicia (Spain), of which ten were public and two were charter schools.

The sample was selected by using convenience sampling. Given the importance of early detection, this study population, unlike other studies, included participants of 12–13 years of age. A total of 3,363 students (50.1% women) aged between 12 and 18 years ($M = 14.60$; $SD = 1.79$) accepted to participate in the study and completed the questionnaire. Thirty-three per cent were aged 12–13 years, 48.5% were aged 14–16 years, and 18.5% were aged 17–18 years. According to their education level, 72.1% were in compulsory secondary education (38.9% in lower secondary education and 33.2% in upper secondary education), and 27.9% were baccalaureate students. The psychometric properties of the CAST were then evaluated using the subpopulation of students who declared having ever consumed cannabis in their life.

Twenty-four questionnaires were excluded due to the high number of unanswered items. Therefore, 3,339 questionnaires were included in the study. Out of 3,339 adolescents, 283 (8.5%) reported having used cannabis in the last 30 days, 522 (15.2%) in the last 12 months and 555 (16.5%) in their lifetime. Data from those 555 adolescents were used for the assessment of the CAST psychometric properties. This decision was based on three main reasons: (1) 91.7% of those who have ever used cannabis in their lifetime also used cannabis in the last year, so they represent almost the same subsample; (2) the authors of the CAST, in the first validation of the test (Legleye et al., 2007), also took the individual's entire life as a reference period; and (3) considering that they are adolescents, the fact that they have ever used cannabis in their lifetime constitutes a risk itself, as pointed out by the original authors (Legleye et al., 2007).

2.2. Questionnaire

An *ad hoc* questionnaire was used to collect data on substance use. The questionnaire consisted of three blocks of questions:

a) The first block inquired about the cannabis habits of consumption. It included three *ad hoc* questions to assess lifetime cannabis use ("Have you ever used marijuana or hashish in your lifetime?"), in the last year ("Have you used marijuana or hashish in the last 12 months?"), and in the last month ("Have you used marijuana or hashish in the last 30 days?").
b) The second block included the *Cannabis Abuse Screening Test* (CAST) and the subscale of *Problem Oriented Screening Instrument for Teenagers* (POSIT-$_{UAS}$) on the use and abuse of substances. The Cannabis Abuse Screening Test (CAST) is a tool developed in France in 2002 as part of the ESCAPAD survey (Beck and Legleye, 2003), consisting of six Likert-type items with five response options ("Never" [0], "Rarely" [1], "Sometimes" [2], "Quite often" [3] and "Very often" [4]). Two correction options are available in the literature: the full CAST (CAST-f), in which each item is scored from 0 to 4, and the final score from 0 to 24; and a binary CAST (CAST-b), in which each item is scored 0 or 1, and the final score from 0 to 6. For the latter, the threshold of positive responses varies depending on the question: for the first two questions the threshold is "sometimes" and for the others "rarely". It was validated for the first time in 2007 by Legleye et al. (2007). The internal consistency achieved was 0.81. The Problem Oriented Screening Instrument for Teeneagers (POSIT) was developed by the National Institute on Drug Abuse as part of the Adolescent Assessment/Referral System (AARS) (Rahdert, 1991), with the aim of detecting specific problems of adolescent drug users/abusers in general. It consists of 139 dichotomous response items that are grouped into 10 subscales. Each of the subscales assesses a different area of the adolescent's life functioning, one of them being the Substance Use and Abuse subscale (POSIT-$_{UAS}$). This subscale consists of 17 items that allow a rapid assessment of young people who may be at risk of developing a possible substance use disorder. The POSIT-$_{UAS}$ subscale was validated in an adolescent population in Spain (Araujo, Golpe, Braña, Varela, & Rial, 2018), obtaining an internal consistency of 0.82. In this study, the internal consistency calculated was 0.84.
c) The third block entailed the sociodemographic characteristics of the population such as sex, age, school year and kind of school (public or charter).

2.3. Procedure

Data were collected using a self-administered questionnaire. Data collection took place in the classrooms of the participating schools with the help of trained psychologists who have experience in these types of studies. A training session was held beforehand with such psychologists, in order to standardize the procedure to be followed as much as possible and to clarify any possible questions at a technical level. The academic staff was not present in the classrooms during the data collection. Likewise, a pilot study was undertaken on 30 students to estimate the time needed to complete the questionnaire and ensure the understandability of the questions by the students. The questionnaire took 10 min to complete and there were no comprehension problems.

Participants were previously informed of the purpose of the study and their participation was completely voluntary and unpaid. The anonymity and confidentiality of the data was ensured. The school directors informed the students' parents of the study and its voluntary nature. The parents could accept or reject the participation of their children in the study. A written informed consent was obtained from the schools as well as from the parents of the participating students before their enrollment in the study. The study was approved by the Bioethics Committee of the University of Santiago de Compostela.

2.4. Analysis

Preliminary data analysis was performed, removing cases with more than 5% of missing values or inconsistent response patterns. The internal consistency of CAST-f was estimated by calculating the Cronbach α and ordinal omega Ω coefficient, while that of CAST-b was determined through KR-20. The corrected Homogeneity Index (CHI) was also calculated for each item, and then Cronbach α was recalculated after the removal of any item. To check the dimensionality of the scales, a Confirmatory Factorial Analysis was performed on each version of the CAST (CAST-f and CAST-b) using the unweighted least squares (ULS) method. ULS does not require assumptions about the distribution of the data and the method is robust with small samples (Forero, Maydeu-Olivares, & Gallardo-Pujol, 2009; Ximénez, 2007).

Criterion validity was assessed through the Pearson and Spearman correlation coefficients with the Substance Use and Abuse Subscale of the *Problem Oriented Screening Instrument for Teenagers* (POSIT-$_{UAS}$). Finally, following the original authors (Legleye et al., 2007), each version's accurate detection ability was examined by using the POSIT-$_{UAS}$ with a cut-off score of 2 as a *Gold Standard.* Sensitivity and specificity indices, positive predictive value (PPV) and negative predictive value (NPV) were calculated. The analyses were completed by estimating the area under the receiver operating characteristic (ROC) curve.

The analyses were carried out using IBM SPSS Statistics 25 and AMOS 23 (IBM SPSS Statistics for Windows, 2017).

3. Results

Table 2 represents the prevalence of problematic cannabis use that was estimated by applying the commonly used cut-off scores for both the CAST-f and CAST-b. Substantial differences in the prevalence of problematic cannabis consumption were observed between CAST-f and CAST-b as well as within the same CAST correction version when applying a different cut-off score. The overall prevalence of problematic cannabis consumption, determined by using the different versions of the

Table 2
Prevalence of Problematic Cannabis Use according to different correction versions and cut-off scores.

		Global (n = 3339)	Male (n = 1666)	Female (n = 1673)	χ^2	12–13 years old (n = 1101)	14–16 years old (n = 1620)	17–18 years old (n = 618)	$\chi 2$
CAST-f	**3** (a)	7.2%	8.8%	5.5%	13.28***	0.7%	7.3%	18.3%	183.04***
	4 (b)	5.5%	6.6%	4.4%	7.14**	0.6%	5.4%	14.7%	150.30***
	7 (c)	3.2%	3.7%	2.8%	1.93	0.5%	2.9%	9.1%	94.81***
CAST-b	**2** (d)	5.8%	6.8%	4.9%	5.34*	0.6%	5.9%	14.9%	146.22***
	4 (e)	2.5%	2.8%	2.1%	1.54	0.4%	2.3%	6.8%	68.10***

(*) $p < .05$; (**) $p < .01$; (***) $p < .001$.
(a) Cut-off score used by Khalily, Schwannauer & Hallahan (2015).
(b) Cut-off score used by Rial et al. (2019).
(c) Cut-off score used by Blankers et al. (2014).
(d) Cut-off score used by the 2019 ESPAD survey.
(e) Cut-off score used by the 2020 ESTUDES survey.

Table 3
Item analysis and descriptive statistics of CAST-f and CAST-b.

	Full CAST			Binary CAST		
	Mean (SD)	IHC	Cronbach α*	Percent positive	IHC	KR-20**
Have you smoked cannabis before midday?	0.93 (1.1)	0.70	0.78	28.5	0.59	0.75
Have you smoked cannabis when you were alone?	0.78 (1.17)	0.69	0.78	23.6	0.58	0.76
Have you had memory problems when you smoked cannabis?	0.53 (0.95)	0.59	0.80	31.9	0.53	0.77
Have friends or members of your family told you that you ought to reduce your cannabis use?	0.32 (0.82)	0.61	0.80	16.8	0.58	0.76
Have you tried to reduce or stop cannabis use without succeeding?	0.32 (0.85)	0.43	0.83	16.2	0.48	0.78
Have you had problems because of your use of cannabis (argument, fight, accident, bad result at school, etc.)?	0.30 (0.77)	0.60	0.80	17.1	0.55	0.77
Total score	3.18 (4.26)					

* Cronbach α after item deletion.
** KR-20 after item deletion.

CAST and cut-off scores, ranged between 2.5% and 7.2%. Wider ranges of prevalence were observed in socio-demographic groups such as males (2.8% to 8.8%) and the 17–18 years age group (6.8% to 18.3%). The average onset age of cannabis use was 14.6 years.

The prevalence of problematic cannabis use was also calculated based on the CAST validation subsample (those who have ever used cannabis in their lifetime). The results show that 41.8% (n = 232) were identified as problematic cannabis users when applying the CAST-f version and a cut-off score of 3; 32.1% (n = 178) with a cut-off score of 4, and 18.6% (n = 103) when using a cut-off score of 7. When employing the CAST-b correction version, 33,9% (n = 188) screened positive with a cut-off score of 2; and 14.6% (n = 81), with a cut-off score of 4.

Likewise, the prevalence data for problematic cannabis use among those who have used cannabis in the last 12 months were very similar. The results show that 44.3% (n = 231) were identified as problematic cannabis users when applying the CAST-f version and a cut-off score of 3; 34.1% (n = 178) with a cut-off score of 4, and 19,5% (n = 102) when using a cut-off score of 7. When employing the CAST-b correction version, 36% (n = 188) screened positive with a cut-off score of 2; and 15,1% (n = 79), with a cut-off score of 4.

Regarding POSIT-$_{UAS}$, 31% (n = 1,036) of the total sample screened positive (cut-off score of 2). Among those who used cannabis in the last 12 months, the percentage rose to 87.4% (n = 485), and 87.7% (n = 458) among the subsample of cannabis users in the last month.

3.1. Descriptive statistics and internal consistency

The internal consistency indicators of CAST-f and CAST-b were acceptable. For CAST-f, the values of Cronbach α and ordinal omega Ω coefficient were 0.83 and 0.82, respectively (Table 3), and for CAST-b,

Table 4
Standardized factor loadings for the one and two-factor models obtained by ULS.

	One-factor model		Two-factor model		
	Full CAST	Binary CAST		Full CAST	Binary CAST
Have you smoked cannabis before midday?	0.83	0.69	F1	0.87	0.75
Have you smoked cannabis when you were alone?	0.81	0.68		0.84	0.72
Have you had memory problems when you smoked cannabis?	0.63	0.61	F2	0.69	0.63
Have friends or members of your family told you that you ought to reduce your cannabis use?	0.65	0.67		0.71	0.69
Have you tried to reduce or stop cannabis use without succeeding?	0.45	0.55		0.49	0.56
Have you had problems because of your use of cannabis (argument, fight, accident, bad result at school, etc.)?	0.64	0.64		0.70	0.65

Table 5
Goodness-of-fit indexes of the one and two-factor models obtained by ULS.

Version	Model	χ^2/gl	GFI	NFI	RFI	AGFI
CAST-full	1-Factor	23.54	0.99	0.98	0.97	0.98
	2-Factor	5.40	0.99	0.99	0.99	0.99
CAST-binary	1-Factor	0.48	0.99	0.98	0.97	0.98
	2-Factor	0.25	0.99	0.99	0.98	0.99

the estimated KR-20 was 0.80. Corrected HI of the items ranged between 0.43 and 0.70 for CAST-f and between 0.48 and 0.59 for CAST-b. Although item 5 showed the least homogeneity index in both versions of the CAST, the elimination of this item does not seem to imply a great improvement in the internal consistency of the scale.

3.2. Construct validity

The construct validity of the two CAST versions (CAST-f and CAST-b) was determined by using a confirmatory factorial analysis where two models were tested: one-factor and two-factor models (Table 4). In the two-factor model, items 1 and 2 were attributed to the same factor and items 3 to 6 were assigned to the other factor. In the one and two-factor models of each of the two correction versions, items 1 and 2 showed the highest loads on their respective factors, while item 5 had the lowest load. The elimination of item 5 did not introduce an improvement in the goodness of fit indicators of the model (Table 5).

Both one-factor and two-factor models showed similar values of the goodness of fit indicators of the model, which were acceptable (Byrne, 2012; Kline, 2016). Although the goodness of fit indicators were slightly better for the two-factor model in CAST-f and CAST-b, the high correlation between the two factors (0.80 in CAST-f and 0.85 in CAST-b) does not justify the assumption of a two-dimensional model.

Table 6
Correlation of CAST-f and CAST-b with the substance use and abuse subscale of the Problem Oriented Screening Instrument for Teenagers (POSIT-$_{UAS}$).

	POSIT	
	Pearson R coefficient	Spearman Rho coefficient
CAST-f	0.54***	0.45***
CAST-b	0.54***	0.47***

(*) $p < .05$; (**) $p < .01$; (***) $p < .001$.

Table 7
Sensitivity, specificity, positive and negative predictive values for the cut-off scores of CAST-f and CAST-b.

	Sensitivity	Specificity	PPV	NPV
CAST-f (Cut-off score of 4 points – Area under the ROC Curve: 0.67; 95% CI: 0.61 - 0.73)				
3	0.45	0.82	0.94	0.18
4	0.35	0.90	0.96	0.17
5	0.28	0.96	0.98	0.16
6	0.23	1	1	0.16
7	0.21	1	1	0.15
CAST-b (Cut-off score of 2 points – Area under the ROC Curve: 0.68; 95% CI: 0.63 - 0.74)				
1	0.55	0.76	0.94	0.20
2	0.37	0.91	0.97	0.17
3	0.25	0.97	0.98	0.16
4	0.17	1	1	0.15

3.3. Criterion validity and detection capability

The correlation coefficients of Pearson and Spearman between the detection results of the instrument under validation (CAST-b and CAST-f) and that of the instrument used as a Gold Standard, substance use and abuse subscale of *Problem Oriented Screening Instrument for Teenagers* (POSIT-$_{UAS}$), are represented in Table 6. The two versions of the CAST showed statistically significant and relatively high correlations with POSIT-$_{UAS}$.

The analysis of the detection capability of the CAST using the POSIT-$_{UAS}$ (2-point cut-off score) as the Gold Standard, showed that CAST-f and CAST-b have low sensitivity and NPV values, however, the specificity and PPV are high (greater than 0.90) (Table 7).

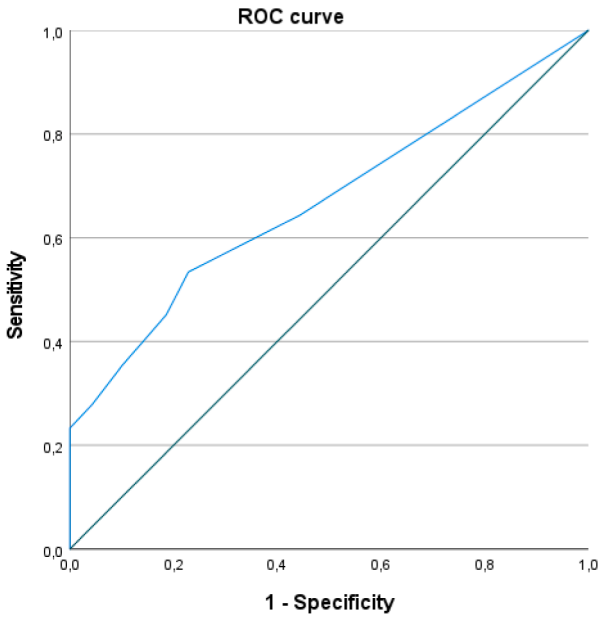
In the case of CAST-b, the 2-point cut-off limit showed the best specificity-sensitivity ratio. In the case of CAST-f, both cut-off limits of 3 and 4 points showed a similar specificity-sensitivity ratio. The ROC curve (Figs. 1 and 2) of true positive values against the false positive values showed a discrete discrimination capability with an area under the curve of 0.67 for CAST-f and 0.68 for CAST-b.

4. Discussion

Early detection of problematic substance use is a current concern for professionals who deal with youths in pediatrics and primary health care services as well as in schools. Given the upward trend in the prevalence of early cannabis use (EMCDDA, 2020b), the availability of short screening tools with validated psychometric properties has become a priority.

The CAST has been widely applied to assess cannabis abuse (Amado et al., 2020; Arias-de la Torre et al., 2020; Blankers et al., 2014; Brunault et al., 2019; Golpe, Gómez, Braña, Varela, & Rial, 2017). It also served as a massive screening tool in national-scale surveys, but not always using the same correction version and the same cut-off points (Beck and Legleye, 2003; EMCDDA, 2020b; Presidenza del Consiglio dei Ministri & Dipartimento per le Politiche Antidroga, 2018; Spanish Observatory on Drugs and Addictions, & Government Delegation for the Spanish National Drugs Plan, 2020). However, despite the fact that several studies assessed the psychometric properties of the CAST as a screening tool for dependence on cannabis or cannabis use disorder (Bastiani et al., 2013; Cuenca-Royo et al., 2012; Gyepesi et al., 2014; Legleye et al., 2012; Legleye, Piontek, & Kraus, 2011, 2013, 2014), the CAST capability for detecting problematic cannabis use in adolescents has been much less studied.

The analyses carried out in this study served to highlight the importance of using an optimal cut-off score for each correction version of the CAST. It has been found that the application of different CAST versions and cut-off scores in interpreting the data collected from the same sample could lead to substantially different results and to inaccurate conclusions. For instance, a statistically significant difference in prevalence between men and women was observed when the CAST-b



Curve coordinates CAST-f

	Sensitivity	1 - Specificity
-1.00	1.000	1.000
.50	.643	.443
1.50	.534	.229
2.50	.452	.186
3.50	.353	.100
4.50	.278	.043
5.50	.233	.000
6.50	.212	.000
7.50	.179	.000
8.50	.142	.000
9.50	.115	.000
10.50	.093	.000
11.50	.072	.000
12.50	.054	.000
13.50	.043	.000
14.50	.031	.000
15.50	.023	.000
16.50	.016	.000
17.50	.008	.000
19.00	.006	.000
20.50	.004	.000
22.50	.002	.000
25.00	.000	.000

Fig. 1. ROC and AUC for CAST-f.

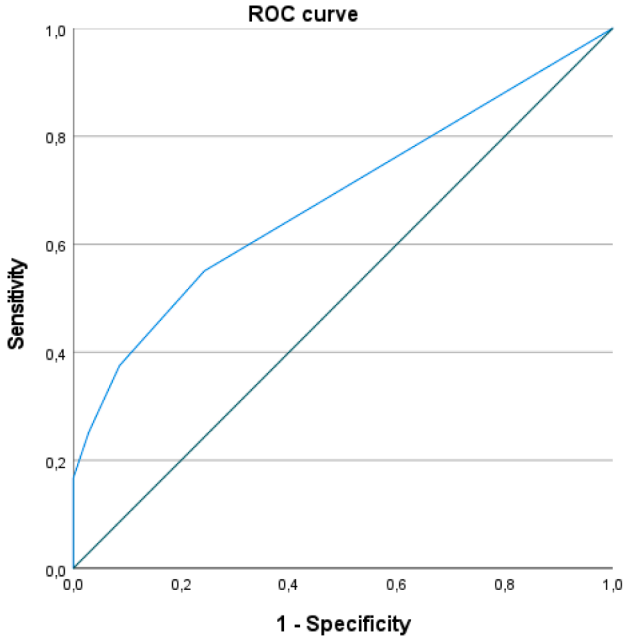
and a 2-point cut-off score were used, but this difference was not observed when a cut-off score of 4 points was applied.

Coinciding with Legleye et al. (2007) and Legleye et al. (2011), our findings suggest that the optimum cut-off scores for determining problematic use in adolescents are: 2 points for CAST-b and 4 points for CAST-f, but not 4 points for CAST-b, as used by the ESTUDES survey (Spanish Observatory on Drugs and Addictions, & Government Delegation for the Spanish National Drugs Plan, 2020), because this would lead to an underestimation of the prevalence. In the case of including participants in the 12–13 age range, the use of a 3-point cut-off score for CAST-f will be the most appropriate due to the higher sensitivity of CAST-f at this cut-off score. CAST-f, in addition to entailing a simpler correction than CAST-b, implies a slight improvement in the early detection capability as showed by the ROC curve.

The indicators of the CAST internal consistency obtained were high and exceeded those obtained in some prior studies (Bastiani et al., 2013; Legleye et al., 2012; Legleye et al., 2011). Most studies had suggested a unidimensional structure of the CAST (Bastiani et al., 2013; Fernandez-Artamendi et al., 2012; Gyepesi et al., 2014), yet other studies suggested a bidimensional CAST model (Cuenca-Royo et al., 2012; Legleye, Eslami, & Bougeard, 2017). In our study, the confirmatory factorial analysis with one and two factors in both versions of the tool (CAST-f and CAST-b) revealed that the goodness-of-fit indicators of the two-factor model are slightly better than those of the one-factor model. Nonetheless, from a practical point of view, the application of two scores (one for each factor) is not justified given the high correlation between the two factors and the high internal consistency of the scale.

The high correlation between the CAST and POSIT-$_{UAS}$ has made it possible to verify the criterion validity of the CAST. When adolescents present a problematic use of cannabis, they are also very likely to engage in the problematic consumption of other substances, which is consistent with the findings from earlier studies (Rial et al., 2019).

The study had some limitations. Despite involving a sample of more than 3,000 participants, the convenience sampling in the Northwest region of Spain does not allow to generalize our findings to the whole Spanish population. Additional national-scale studies are needed to estimate the prevalence of problematic cannabis use in Spain. In addition, the estimated prevalence was not controlled for potentially confounding variables such as socioeconomic level, mental health, and clinical features like intelligence quotient. As it is the case of all self-administered questionnaires, the answers of the participants might be affected by social desirability bias where the respondent might report their true behaviors towards cannabis. However, it should be noted that different experts in the field of addictive behaviors have pointed out that self-report measures are reliable and even preferable to other methods when evaluating substance use in the youth population (Babor, Kranzler, & Lauerman, 1989; Winters, Stinchfield, Henly, & Schwartz, 1990). Finally, the results obtained indicate that the CAST is not a sensitive tool for detecting problematic cannabis use. The low sensitivity obtained may be due to the used Gold Standard. POSIT-$_{UAS}$ is a general substance



Curve coordinates CAST-b

	Sensitivity	1 - Specificity
-1.00	1.000	1.000
.50	.551	.243
1.50	.375	.086
2.50	.252	.029
3.50	.167	.000
4.50	.099	.000
5.50	.039	.000
7.00	.000	.000

Fig. 2. ROC and AUC for CAST-b

problematic screening tool that can yield positive results for the use of substances other than cannabis such as alcohol or tobacco. Future studies are advised to use a Gold Standard that allows a more precise examination of the screening capability for problematic cannabis use, especially in the onset of early cannabis use, where levels of CUD or CD are expected to be low. Data collection based on individual interviews and using a tool such as the Adolescent Diagnostic Interview (ADI) could serve as the above-mentioned Gold Standard.

In conclusion, the present work provides evidence about the psychometric properties of the CAST for the screening of problematic cannabis use in the adolescent population. To carry out a massive screening in Spain, it is proposed to update and adapt the optimal cut-off points for each correction version ("4" for CAST-f and "2" for CAST-b). Despite the observed limitations, the CAST constitutes a valid and reliable tool that can be used in the context of early cannabis use in adolescents, within the framework of prevention policies, both for periodic massive screening as well for case finding.

CRediT authorship contribution statement

Antonio Rial: Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing. **Nuria García-Couceiro:** Writing – original draft, Writing – review & editing, Visualization. **Patricia Gómez:** Writing – review & editing. **Narmeen Mallah:** Writing – review & editing. **Jesús Varela:** Funding acquisition, Methodology, Formal analysis, Validation. **Gerardo Flórez-Menéndez:** Resources, Investigation. **Manuel Isorna:** Conceptualization, Resources, Data curation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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