International Journal of Mental Health and Addiction
https://doi.org/10.1007/s11469-025-01567-2

ORIGINAL ARTICLE

Explaining Avoidance of Simultaneous Alcohol and Cannabis Use: An Extended Theory of Planned Behavior Model Including Non-deliberative Processes

Belén Valle del Vera[1,2] · Alberto Parrado-González[3,4] · José Carmona-Márquez[5,6] · Fermín Fernández-Calderón[5,6]

Received: 6 July 2025 / Accepted: 4 October 2025
© The Author(s) 2025

Abstract

Simultaneous alcohol and cannabis use (SAC) poses greater health risks than using each substance separately or concurrently. This two-wave prospective study examined (1) the Theory of Planned Behavior (TPB) capacity to explain the frequency of avoiding SAC use; (2) whether adding past behavior and habit strength—non-deliberative processes—improved prediction; and (3) model invariance across sex and college status. A community sample of 378 young adults (60.3% men, $M_{age}=21.02$, $SD=2.12$) completed baseline and 3-month follow-up questionnaires. The TPB explained 55.9% of the variance in intention and 31.4% in behavior. Adding habit strength and past behavior raised explained variance to 73.6% and 49.9%. These non-deliberative factors were the strongest predictors, reducing the effect of traditional TPB components. The model's predictive capacity was invariant across gender and educational status. While the TPB provides a strong framework for understanding health-promoting behaviors, our results highlight the importance of considering both automatic and reasoned processes.

Keywords Simultaneous alcohol and cannabis (SAC) use · Health-promoting behaviors · Theory of Planned Behavior · Non-deliberative processes · Young adults

✉ Fermín Fernández-Calderón
fermin.fernandez@dpces.uhu.es

1 Institute of Psychological Research, IIPsi-CONICET-UNC, Córdoba 21071, Argentina

2 Faculty of Psychology, National University of Córdoba, Córdoba 21071, Argentina

3 Faculty of Health Sciences, International University of La Rioja, Logroño 21071, Spain

4 Department of Social, Developmental and Educational Psychology, Avenida de Las Fuerzas Armadas, University of Huelva, PB 2-28, Campus de "El Carmen, 21071 S/NHuelva, Spain

5 Department of Clinical and Experimental Psychology, Avenida de Las Fuerzas Armadas, University of Huelva, PB 2-28, Campus de "El Carmen, 21071 S/NHuelva, Spain

6 Research Center On Natural Resources, Health and the Environment, Avenida de Las Fuerzas Armadas, University of Huelva, PB 2-28, Campus de "El Carmen, 21071 S/NHuelva, Spain

Published online: 11 November 2025

Alcohol and cannabis use are highly prevalent worldwide (United Nations Office on Drugs and Crime [UNODC], 2023; World Health Organization [WHO], 2018), especially among young adults, who often consume both substances simultaneously—a pattern known as simultaneous alcohol and cannabis (SAC) use. SAC use has steadily increased in recent years, with U.S. data showing that 20–25% of young adults engage in this behavior (Lee et al., 2022) and rates reaching up to 70% among those who use both substances (Jackson et al., 2020; White et al., 2019). Compared to alcohol or cannabis use alone or concurrent alcohol and cannabis (CAC) use (i.e., without overlapping effects), SAC use entailed greater risk (Lee et al., 2022). Among young adults, SAC use is associated with heavier consumption, increased substance-related consequences, and increased engagement in risky behaviors, such as impaired driving (Cummings et al., 2019; Duckworth & Lee, 2019; Jackson et al., 2020; Thompson et al., 2021). Understanding and promoting SAC avoidance is therefore critical.

The Theory of Planned Behavior (TPB; Ajzen, 1991) is a widely used framework for predicting health-related behaviors (Ajzen, 2011, 2020), emphasizing the role of cognitive processes in health-related decision-making (Conner & Sparks, 2015). Its core premise (Ajzen, 1991, 2002a) is that behavior (e.g., avoiding SAC use) is primarily predicted by behavioral intention (e.g., the intention to avoid SAC use). Intentions are, in turn, shaped by three belief-based constructs: attitudes (positive or negative evaluations of the behavior), subjective norms (the extent to which an individual believes that important others would approve or disapprove of the behavior under consideration), and perceived behavioral control (PBC; beliefs about the ease or difficulty of performing the behavior). PBC may also exert a direct influence on behavior. The theory further distinguishes two components within PBC: self-efficacy (confidence in one's ability to execute the behavior) and perceived control (the perception of having control over executing the behavior) (Ajzen, 2002a).

Meta-analyses on TPB applications to different behaviors indicate that it reliably predicts both intention and behavior, explaining 40–50% of the variance in intention and 25–40% in behavior (Armitage et al., 2001; Hagger et al., 2016; McEachan et al., 2011). Intention consistently emerges as the strongest predictor of behavior, with PBC also playing a significant role. In predicting intention, across a wide range of behaviors, attitude shows the strongest association, followed by PBC and subjective norms.

Systematic reviews support the TPB's utility in predicting substance-related behaviors (see Cooke et al., 2016; Hagger & Hamilton, 2024; Topa & Moriano, 2010), though its predictive power varies by behavior type—health-risk or health-promoting (Cooke et al., 2016; Hagger & Hamilton, 2024; McEachan et al., 2011). For instance, the attitude–intention relationship has been found to be stronger for alcohol-related health-risk behaviors (e.g., heavy drinking) than for alcohol-related health-promoting behaviors (e.g., alcohol avoidance), whereas the opposite pattern has been observed for the subjective norms–intention link (i.e., it resulted stronger for alcohol abstinence than for alcohol intoxication, Cooke et al., 2016). In this regard, it is particularly relevant to examine how the theory applies to a health-promoting behavior such as avoiding SAC use.

It is noteworthy that most TPB studies on alcohol and cannabis field have focused on health-risk behaviors—such as typical frequency or quantity of use (Hagger et al., 2012), risky drinking patterns (Cooke et al., 2007; Norman, 2011), and substance-related risk behaviors like driving under the influence of cannabis (Earle et al., 2020). In contrast, relatively few studies have examined the TPB's ability to explain substance-related health-promoting behaviors, such as avoiding alcohol use (Ajzen & Sheikh, 2013; Rise & Wilhelmson, 1998), avoiding excessive alcohol consumption (Gagnon et al., 2012), avoiding drinking and driving (Moan & Rise, 2011), or using protective behavioral strategies for alcohol use (Fernández-Calderón et al., 2025), ecstasy (Davis & Rosemberg, 2016), and other substances (Murphy et al., 2021). For instance, Fernández-Calderón et al. (2025) found that TPB variables predicted 58–68% of the intention to use alcohol-related protective strategies and 18–50% of their use 2 months later, with attitude as the strongest predictor, supporting the TPB's relevance for health-promoting behaviors. Building on these and other findings that have identified a similar pattern of relationships for other substance-related protective behaviors (e.g., Davis & Rosemberg, 2016; Murphy et al., 2021), it is expected that TPB constructs will also predict the frequency with which individuals avoid SAC use, with attitudes exerting the strongest influence on intentions, followed by subjective norms and PBC.

Although widely applied, the TPB has been critiqued for overemphasizing conscious, deliberative processes. Specifically, it has been argued that many behaviors are not exclusively the result of reasoned decision-making but are also influenced by automatic, non-conscious processes shaped by past experiences (Conner & Sparks, 2015; Sheeran et al., 2013), as suggested by dual-process theories (Strack & Deutsch, 2004). Expanding the TPB to include these non-deliberative processes could enhance its explanatory power (Hagger et al., 2023). Habit, in particular, has been shown to increase explained variance in behavior while weakening TPB constructs' effects (Fernández-Calderón et al., 2025; Hamilton et al., 2020; Norman, 2011). For instance, Fernández-Calderón et al. (2025) found that adding habit increased the explained variance in intention by 20% for five alcohol-protective behaviors. In this regard, it is expected that the inclusion of non-deliberative components in the model will enhance the TPB's ability to explain substance-related health-promoting behaviors, such as the avoidance of SAC use, while attenuating the influence of belief-based constructs on intentions (i.e., attitudes, subjective norms, and PBC).

While past behavior is often used as a proxy for habit (Ouellette & Wood, 1998), besides contributing to habit, it can also influence future behavior by shaping beliefs and intentions (Ajzen, 2002b; Hagger et al., 2018). Studies incorporating measures of both past behavior and habit strength show that each independently affects future behavior, with past behavior also exerting indirect effects via habit and TPB constructs (Brown et al., 2020; Hamilton et al., 2020). However, no studies to date have examined both variables in relation to substance-related health-promoting behaviors, such as the frequency of avoiding SAC use. Based on the available evidence, both constructs are expected to directly influence the frequency of avoiding SAC use.

Previous research has shown that SAC use is more common and frequent among men than women (Lee et al., 2022; Tomko et al., 2023). In the substance use domain, although findings are mixed, sex appears to moderate the relationships among TPB constructs. For example, in explaining alcohol consumption (a health-risk behavior), the attitude-intention relationship is stronger among women (Cooke et al., 2016; Kyrrestad et al., 2022). Conversely, when predicting the intention to avoid drink driving (a health-promoting behavior), this relationship was significant only for males (Moan & Rise, 2011). Research on sex invariance in TPB's predictive power for substance-related health-promoting behaviors is scarce, with only one study (Fernández-Calderón et al., 2025) reporting mixed results: the model generally functioned similarly for men and women, but the attitude-intention relationship was stronger for men when total strategies employed was the outcome. These mixed findings suggest the importance of further investigating potential sex differences in the way the model explains protective behaviors.

Additionally, it is important to highlight that the college environment shapes young adults' normative beliefs, attitudes, and substance use behaviors differently from their non-college peers (Merrill & Carey, 2016; Schulenberg & Maggs, 2002). SAC use is more prevalent among college-educated individuals or current students (Linden-Carmichael et al., 2020; Patrick et al., 2019), whereas the use of cannabis-related protective strategies (such as avoiding SAC use) is more common among non-college youth (Sánchez-García et al., 2024). Research also suggests that college students are exposed to norms promoting higher alcohol and cannabis consumption and riskier behaviors (Arbour-Nicitopoulos et al., 2010; Graupensperger et al., 2023). Although TPB model invariance by college status remains unexplored, a meta-analysis found that education level moderates the effectiveness of TPB interventions (Steinmetz et al., 2016), being more effective for those with high school or college education than those with lower educational backgrounds. This underscores the importance of examining whether the TPB functions similarly across different educational levels in explaining substance-related behaviors.

As noted, the TPB's predictive power varies by behavior type, context, and some sociodemographic factors. It is therefore important to examine how TPB constructs function in explaining substance-related health-promoting behaviors across sex and college status. Such insights could guide the development of targeted interventions, tailored to group-specific needs to enhance their effectiveness.

In this way, this two-wave prospective study aimed to (1) examine the explanatory value of the TPB model (Model 1) in explaining the frequency with which individuals avoid SAC use; (2) evaluate the explanatory power of an extended TPB model (Model 2) incorporating past behavior and habit strength—two measures that reflect implicit processes—in predicting this health-promoting behavior; and (3) explore whether the explanatory value of the extended TPB model (Model 2) varies across sex and college status.

Based on prior research, we hypothesize that (1) TPB constructs will predict the frequency with which individuals avoid SAC use (Cooke et al., 2016; Hagger & Hamilton, 2024; McEachan et al., 2011). Attitudes will exert the greatest impact on intentions, followed by subjective norms and PBC. Intentions and PBC will directly impact the frequency of avoiding SAC use at follow-up. Belief-based constructs will have an indirect effect on future behavior through intentions; (2) the inclusion of past behavior and habit strength in the model will enhance the explained variance in intentions and actual behavior (Hagger et al., 2023) and will attenuate the effect of belief-based constructs on intentions (Fernández-Calderón et al., 2025; Hamilton et al., 2020). Both constructs will directly affect the frequency of avoiding SAC use, independent of intentions, and past behavior is expected to impact the belief-based constructs of the TPB (Brown et al., 2020; Hamilton et al., 2020). Habit strength will mediate the relationship between the frequency of avoiding SAC use at baseline and follow-up; and (3) given the mixed findings on the differential explanatory value of the TPB across sex and college status, no specific predictions were made regarding these variables.

Methods

Participants

Sample size was estimated using the power4SEM Shiny app. With a significance level of .05, a minimum sample size of 427 was required to achieve a power of .80 to reject the null hypothesis of not-good fit (H0: RMSEA $\geq$ .07) if the extended TPB model exhibited close fit in the population (H1: RMSEA = .01). The final sample size was increased by 40% to account for non-response attrition at follow-up. A community-based sample of 616 young adults residing in Huelva or Seville was recruited. To be eligible, participants had to be between 18 and 25 years old and have consumed cannabis at least once in the last month. Four participants were excluded from the baseline sample due to inconsistent response patterns, resulting in a final baseline sample of 612.

From baseline sample, 505 (i.e., 82.5%) completed the follow-up assessment 3 months later. No significant differences were found between follow-up participants and non-participants in terms of sex, age, attitude, subjective norms, perceived control, and frequency of alcohol use (all $ps > .05$). However, non-respondents and respondents differed in the quantity and frequency of cannabis use (12.47 vs. 7.66, $t = 4.392$, $p < .001$ and 21.23 vs. 17.51, $t = 3.243$, $p < .01$ for quantity and frequency, respectively), the quantity of alcohol use (19.74 vs. 15.07, $t = 2.749$, $p < .01$), self-efficacy (17.56 vs. 18.49, $t = 2.387$, $p < .05$), intention to avoid SAC use (11.44 vs. 12.91, $t = 2.244$, $p < .05$), habit strength (6.99 vs. 8.20, $t = 2.762$, $p < .01$), and the frequency of avoiding SAC use at baseline (3.21 vs. 3.66, $t = 2.527$, $p < .05$). Additionally, non-college students were more likely to drop out of the study than college students (23% vs. 9%, respectively, $\chi^2 = 20.1$, $p < .001$).

Of those who completed both assessments, four were excluded for identifying with a sex other than male or female, as these cases could not be included in the invariance analysis because the subgroup sample size was too small ($n = 4$). Only participants who reported using both alcohol and cannabis at both time points were retained for analysis. Thus, the final analytical sample consisted of 378 young adults (60.3% men) with a mean age of 21.02 years ($SD = 2.12$). When completing the baseline assessment, 46.8% were studying at university, the main sources of income were family allowance (49.2%) and employment (34.9%), and 67.5% were cohabitating with their parents. Most participants only studied (43.1%) or combined study with work (30.7%). The mean number of days of alcohol and cannabis use in the past month at baseline was 8.8 ($SD = 6.9$) and 17.8 ($SD = 10.6$), respectively. Participants consumed an average of 17.5 Standard Drinking Units of alcohol ($SD = 15.2$) and 7.5 g of cannabis ($SD = 8.8$) in a typical week.

Instruments

Theory of Planned Behavior Constructs (Baseline)

The TPB constructs were assessed using an adapted version of the instrument developed by Fernández-Calderón et al. (2025) to measure TPB constructs related to alcohol-related protective strategies. This instrument follows Ajzen's (2006, 2013) guidelines and includes three items for attitudes (e.g., *Avoiding mixing cannabis and alcohol is important to me*), three for subjective norms (e.g., *Most of my friends think that I should avoid mixing cannabis and alcohol*), two for perceived control (e.g., *When I use cannabis, avoiding mixing cannabis and alcohol is up to me*), three for self-efficacy (e.g., *If I wanted to, I would be able to avoid mixing cannabis and alcohol*), and three for intention (e.g., *In the next three months, when I use cannabis, I will avoid mixing it with alcohol*). Each item is rated on a 7-point Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Total scores were calculated for each construct by aggregating individual item scores. Cronbach's alpha values were .73 for attitude, .74 for subjective norms, .72 for perceived control, .75 for self-efficacy, and .91 for intention.

Habit Strength (Baseline and Follow-Up)

Following the recommendations for using brief measures of habit strength (Gardner et al., 2024), we employed the two-item habit strength measure developed by Fernández-Calderón et al. (2025). This measure assesses two core components of habitual behavior (Gardner, 2012): automaticity (*Automatically, when I use cannabis, I avoid mixing it with alcohol*) and routine (*When I use cannabis, it is customary for me to avoid mixing it with alcohol*). Each item is rated on a 7-point Likert scale (1 = *strongly disagree*, 7 = *strongly agree*), and the scores are summed to determine habit strength. This measure has shown high reliability (α = .88–.95) in previous studies assessing TPB constructs for alcohol-related protective strategies (Fernández-Calderón et al., 2025). In this study, Cronbach's alpha values for habit strength at baseline and follow-up were .87 and .89, respectively.

Avoiding SAC Use (Baseline and Follow-up)

An item from the Protective Behavioral Strategies Scale (PBSS-20; Treloar et al., 2015) was used to assess the frequency of avoiding SAC use both at baseline (i.e., past behavior) and follow-up (i.e., actual behavior). Specifically, participants were asked to report how often they avoided mixing alcohol with cannabis in the past month, using a scale ranging from 1 (*never*) to 6 (*always*).

Cannabis Use Measure (Baseline)

Participants reported the number of days they used cannabis in the past 30 days. The Cannabis Use Grid—MUG (Pearson et al., 2023) was used to assess typical weekly quantity, dividing each day into six 4-h blocks (42 total). Participants recorded grams of marijuana and hashish consumed per block, aided by images showing reference quantities (0.25–2.5 g) with bottle caps for scale (available in Sánchez-García et al., 2024). Participants were instructed to report their use of each substance separately for a typical week in the past month. Total cannabis use was calculated by summing both substances for a typical week.

Alcohol Use Measure (Baseline)

Participants reported alcohol use frequency (number of drinking days in the past 30 days). A modified Daily Drinking Questionnaire (DDQ; Collins et al., 1985) assessed typical weekly consumption. Using images of six beverage types, participants indicated drinks per day during a typical week. Reported amounts were converted into Standard Drinking Units (SDU; 1 SDU = 10 g pure alcohol; Rodriguez-Martos et al., 1999).

Procedure

Recruitment was conducted using a targeted sampling procedure (Watters & Biernack, 1989) between June 2022 and July 2023 and occurred in two phases. First, qualitative interviews with cannabis-using young adults identified key locations (e.g., parks, party areas) across different districts in Seville and Huelva for reaching potential participants. Then, three psychologists with psychosocial research experience visited these districts and sites and approached individuals who, apparently, met the established age criteria (i.e., 18–25 years old). To ensure privacy during the initial face-to-face contact, recruiters met participants in secluded areas and asked about their age and whether they had used cannabis in the past year. Those who reported cannabis use in the past year and agreed to participate were later contacted by telephone to confirm their eligibility based on the cannabis use criterion (i.e., using cannabis at least once during the previous 30 days).

This sampling strategy was supplemented by two additional approaches. First, posters with study information were displayed in selected locations. Second, snowball sampling (Goodman, 1961), as part of the targeted sampling procedure (Vervaeke et al., 2007), was utilized to recruit participants meeting the inclusion criteria. Each participant could nominate up to five peers, limiting nominations to prevent sample homogeneity. Sampling characteristics (i.e., age, gender, college status, and cannabis use frequency) were monitored to adjust recruitment and ensure heterogeneity. Of the baseline sample, 22.0% were recruited directly, 32.5% via nominations, and 45.5% responded to posters.

For the 3-month follow-up, a mixed-methods approach (Dillman et al., 2014) was applied to maximize response rates, a strategy previously shown to be effective (Fernández-Calderón et al., 2022, 2025). Participants received a WhatsApp pre-notification 1 week before their scheduled follow-up, informing them that they would receive a call in 2–3 days to schedule a face-to-face appointment within the following 3–7 days. Non-respondents were contacted twice more: via WhatsApp (2–3 days later) and by phone call (2–3 days after the WhatsApp message).

Consistent procedures were used at baseline and 3-month follow-up. On both occasions, participants provided written informed consent before completing a self-administered paper-and-pencil questionnaire individually or in small groups (maximum of five people) in designated rooms at the University of Huelva and collaborating organizations in Seville specialized in substance-related issues. An interviewer was present to assist as needed. Participants received a €15 Amazon voucher per session as compensation.

All study protocols were approved by the Regional Committee for Bioethics Research of Andalusia (Regional Ministry of Health, Andalusia, Spain) under code 0283-N-22 and comply with APA ethical standards for human research.

Data Analysis

Descriptive analyses and correlations were conducted using SPSS v24 (IBM Corp, 2016). Two separate path analyses were conducted using Mplus 7.0 (Muthén & Muthén, 2015) to test the hypothesized model relationships. Model 1 assessed the original TPB framework as a predictor of SAC avoidance frequency. Model 2 extended this framework by including past behavior and habit strength. All direct and indirect effects tested are depicted in Fig. 1. Mediation was assessed using the bootstrapping approach recommended by Hayes (2013), with 10,000 bootstrap samples to generate confidence intervals for indirect effect tests. In both models, we controlled for age, as well as baseline frequency and quantity of alcohol and cannabis use, by including these variables as covariates.

The path analysis models were estimated using the robust Maximum Likelihood (ML) method. Model goodness-of-fit was assessed through chi-square and additional indices that are less sensitive to sample size, including the comparative fit index (CFI), the Tucker–Lewis index (TLI), the standardized root mean square residual (SRMR), and the root mean square error of approximation (RMSEA). A cut-off value of .90 or above for the CFI and TLI is

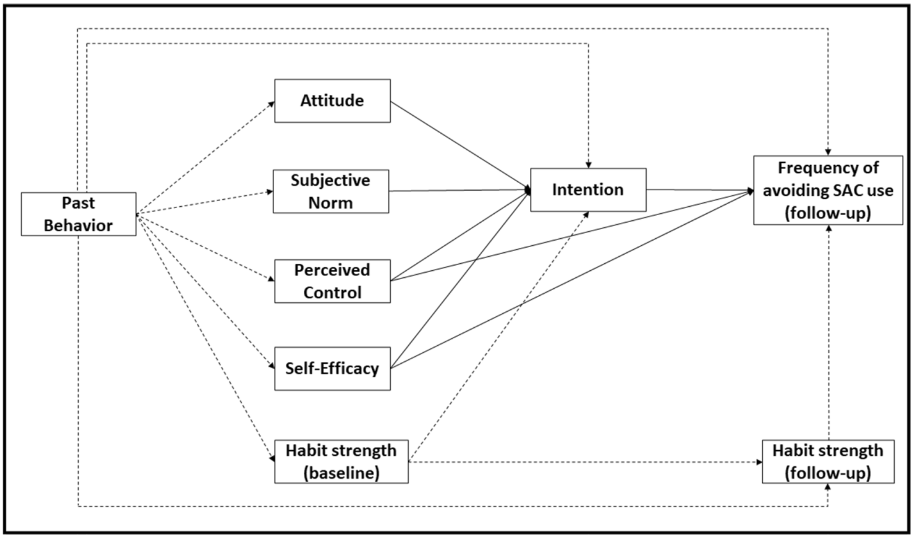


Fig. 1 Tested models, Note: Solid lines represent effects analyzed in the original (Model 1) and extended (Model 2) TPB models. Dotted lines indicate relationships examined only in the extended TPB model (Model 2)

indicative of an acceptable model, and values approaching .05 and .08 or less for the SRMR and RMSEA, respectively, are deemed satisfactory for a well-fitting model (Kline, 2005).

Finally, to assess the potential invariance of the extended Model 2 across sex and college status, a multigroup path analysis was employed. First, we tested Model 2 separately for men ($n=228$) and women ($n=150$), as well as for college ($n=177$) and non-college ($n=201$) students, to determine whether the model provided a good fit within each subgroup. The multigroup path analysis began with a baseline model without constrained parameters in each case. Next, constraints were applied to the model (testing for invariance of regression parameters). To establish invariance, both models must demonstrate an adequate fit, and the difference in fit between them should not be statistically significant. The scaled difference test proposed by Satorra and Bentler (2010) was employed to compare robust chi-square values.

Results

Descriptive Data and Bivariate Analysis

Table 1 presents descriptive statistics and correlations among the study variables. All correlations were statistically significant. The strongest correlations with follow-up behavior were observed for intention, follow-up habit, past behavior, and baseline habit.

Path Analysis Models

The original TPB model (Model 1) showed a good fit to the data ($\chi^2=5.432$, $df=2$, $p=.066$, CFI = .995; TLI = .886; SRMR = .012; RMSEA = .068). The model explained

Table 1 Descriptive and correlation analysis of study variables

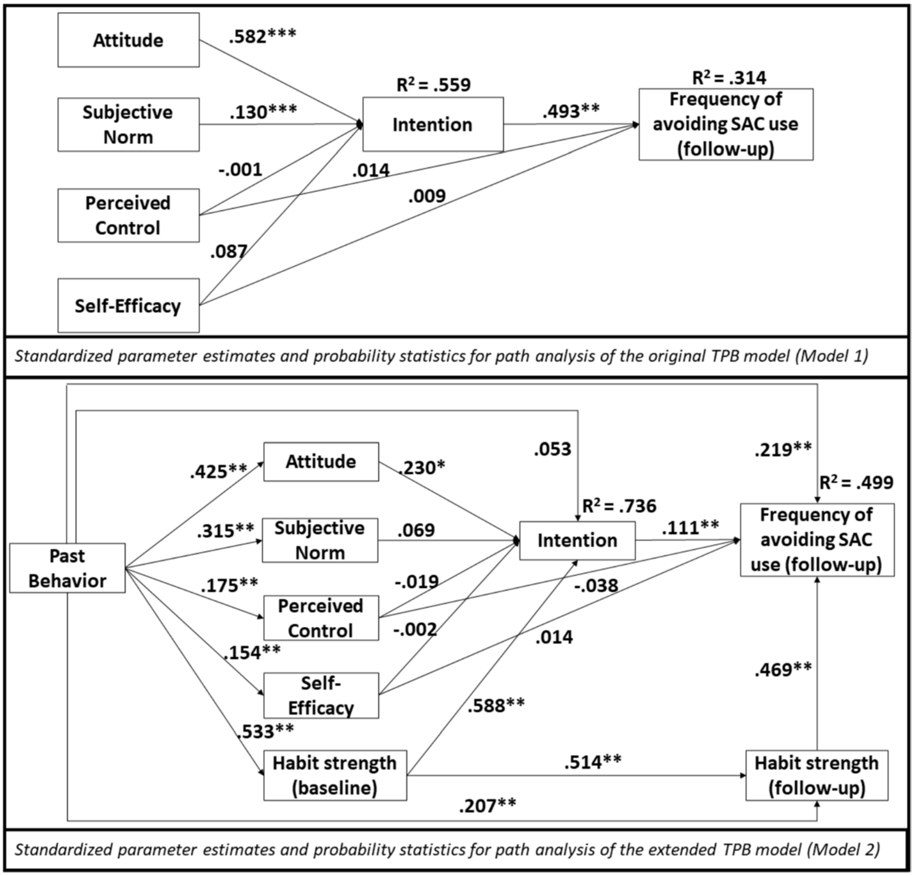
Construct (potential rank)	*M* (*SD*)	1	2	3	4	5	6	7	8
1. Attitude (3–21)	13.97 (4.63)	-							
2. Injunctive norm (3–21)	12.72 (4.65)	.542***	-						
3. Behavioral control (2–14)	12.82 (2.07)	.226***	.144**						
4. Self-efficacy (3–21)	18.32 (3.48)	.242***	.139**	.617***					
5. Intention (3–21)	12.42 (5.75)	.705***	.488***	.254***	.298***				
6. Past behavior (1–6)	3.44 (1.53)	.456***	.348***	.251***	.243***	.546***			
7. Baseline habit (2–14)	7.90 (3.94)	.677***	.448***	.283***	.347***	.827***	.582***		
8. Follow-up habit (2–14)	7.98 (4.21)	.548***	.401***	.213***	.221***	.638***	.521***	.652***	
9.Frequency of avoiding SAC use at follow-up (1–6)	3.59 (1.6)	.426***	.337***	.146**	.176**	.532***	.529***	.527***	.658***

Note: *M* mean, *SD* standard deviation, ****p*<.001, **p*<.01

55.9% and 3.4% of the variance in the intention to avoid SAC use and the frequency of avoiding SAC use at follow-up. As illustrated in Fig. 2 (upper section), among the TPB constructs, only attitudes and subjective norms were positive and significantly related to intention, while neither perceived control nor self-efficacy demonstrated significant associations. Finally, the intention to avoid SAC use was positive and significantly related to the frequency with which individuals avoided SAC use 3 months later.

Model 2, which incorporated past behavior and habit strength, also showed a good fit to the data ($\chi^2 = 22.354$, $df = 8$, $p < .01$; CFI = .991; TLI = .906; SRMR = .018; RMSEA = .069). The explained variance was 73.6% for intention and 49.9% for behavior. As seen in Fig. 2 (bottom), adding past behavior and habit strength to the model attenuated the attitudes–intention relationship and nullified the subjective norms–intention relationship. Attitudes were the only TPB construct significantly associated with intention. Past behavior was significantly related to all constructs within the model except for intention. Habit strength at baseline showed significant relationships with behavioral intention and follow-up habit. The frequency of avoiding SAC use at follow-up showed significant direct relationships with intentions, past behavior, and habit strength at follow-up.

Focusing on the indirect effects, we found no indirect effect of attitudes, subjective norms, perceived control, and self-efficacy on behavior through intention, nor indirect effects of past behavior on actual behavior through belief-based constructs and intentions (all *ps* > .05). We did find indirect effects of baseline habit on the frequency of avoiding SAC use at follow-up, mediated by follow-up habit ($\beta = .241$, $p < .001$) and intention ($\beta = .065$, $p < .05$). Additionally, a statistically significant indirect effect of past behavior on follow-up behavior through habit at both time points ($\beta = .128$, $p < .001$) was found.



Standardized parameter estimates and probability statistics for path analysis of the original TPB model (Model 1)

Standardized parameter estimates and probability statistics for path analysis of the extended TPB model (Model 2)

Note: $^{***}p < .001$; $^{**}p < .01$; $^{*}p < .05$

Fig. 2 Standardized parameter estimates and probability statistics for path analysis in the original and extended TPB models. Note: $^{***}p < .001$; $^{**}p < .01$; $^{*}p < .05$

Model Invariance Across Sex and College Status

First, model fit was evaluated separately for each subgroup (males/females and college/non-college students). As shown in Table 2, the fit indices for each group were satisfactory. The multigroup analysis without constraints also indicated adequate fit values. The comparison between the unconstrained and constrained models revealed no significant differences, suggesting that the model is invariant across sex ($\Delta\chi^2 = 20.512$, $\Delta df = 14$, $p > .05$) and college status ($\Delta\chi^2 = 13.241$, $\Delta df = 14$, $p > .05$).

Discussion

This study supports the TPB's utility in explaining how often young adults who use alcohol and cannabis avoid SAC use. Incorporating non-deliberative predictors (past behavior and habit strength) into an extended TPB model significantly improved the explained variance

Table 2 Model invariance across gender and college status for the extended TPB model (Model 2)

	Goodness of fit							Multigroup comparison			
	χ^2	df	χ^2/df	***p***	CFI	TLI	RMSEA	SRMR	$\Delta\chi^2$	Δdf	***p***
Males ($n=228$)	14.486	8	1.810	.070	.993	.926	.060	.019			
Females ($n=150$)	13.623	8	1.703	.092	.991	.907	.068	.019			
Multi-group unconstrained model	28.190	16	1.762	.030	.992	.918	.064	.019	20.512	14	.115
Multi-group constrained model	48.567	30	1.619	.017	.988	.934	.057	.026			
College students ($n=77$)	13.310	8	1.664	.101	.992	.923	.061	.018			
Non-college students ($n=201$)	15.422	8	1.928	.051	.991	.912	.068	.018			
Multi-group unconstrained model	28.746	16	1.797	.025	.992	.917	.065	.018	13.241	14	.508
Multi-group constrained model	41.502	30	1.383	.078	.993	.960	.045	.023			

Note: χ^2 = chi-square; *df* = degrees of freedom; χ^2/df = chi-square divided by degrees of freedom; $p = p$-value; CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; RMSEA = Root Mean-Square Error of Approximation; SRMR = Standardized Root Mean-Square Residual of both intention and actual behavior, with these factors emerging as the strongest predictors. Their inclusion also reduced the influence of deliberative TPB components. Further, the predictive capacity of this extended TPB model remained invariant across sex and college status, suggesting that TPB-based interventions may be similarly effective across these sociodemographic groups.

Consistent with previous meta-analyses on the TPB's predictive value for health-promoting behaviors (Albarracín et al., 2001; Hagger et al., 2002, 2016; McEachan et al., 2011), the original TPB model accounted for 55.9% of the variance in intention and 31.4% in the actual avoidance of SAC use. As hypothesized, attitudes emerged as the most significant explanatory factor of intentions, supporting prior research on their key role in explaining substance-related protective behaviors, such as avoiding binge drinking (Gagnon et al., 2012) and utilizing protective behavioral strategies for alcohol use (Fernández Calderón et al., 2025) and ecstasy use (Davis & Rosenberg, 2016). Given the effectiveness of interventions targeting attitudes across diverse health contexts (Steinmetz et al., 2016), these findings further emphasize their relevance as a promising target for future interventions in promoting SAC avoidance.

Subjective norms also significantly predicted intention to avoid SAC use, though with a weaker effect, and only within the original TPB model. This aligns with previous reviews (e.g., Armitage & Conner, 2001; Hagger et al., 2002; McEachan et al., 2011) showing that subjective norms are more predictive of health-risk behaviors than of health-promoting behaviors (e.g., avoiding SAC use). Furthermore, the weak effect of subjective norm in our study may be explained by the fact that others' approval tends to be more influential during adolescence and declines with age (Hagger et al., 2022; McEachan et al., 2011).

Contrary to our hypothesis, PBC was not significantly associated with intention or behavior. This partially aligns with studies where PBC failed to explain ecstasy protective behaviors (Davis & Rosenberg, 2016) or in predicting the use of protective behavioral strategies for alcohol, particularly when non-conscious components were considered (Fernández Calderón et al., 2025). Some authors suggest that PBC may function better as a moderator rather than a direct predictor of the attitude-intention, subjective norms-intention (Ajzen, 2020; La Barbera & Ajzen, 2020), or intention-behavior relationships (Hagger et al., 2022), a possibility that future research should explore.

Consistent with previous research (Hagger et al., 2016, 2023), adding habit strength and past behavior into the model increased the explained variance in intention (from 55.9% to 73.6%) and in the frequency of avoiding SAC use (from 31.4% to 49.9%). As expected (Brown et al., 2020; Fernández-Calderón et al., 2025; Hamilton et al., 2020), incorporating non-deliberative constructs attenuated, or even nullified, the effect of deliberative components of the theory: the attitude-intention link was nearly three times weaker and the intention-behavior association dropped to about one-fifth of its original strength in the extended model. Meanwhile, and in line with prior findings on health-promoting behaviors (Brown et al., 2020; Fernández-Calderón et al., 2025), habit emerged as the strongest predictor of behavior, with its coefficient being twice that of past behavior and four times greater than that of intention. This pattern aligns with dual-process models (Strack & Deutsch, 2004) and emphasizes that the decision to avoid mixing alcohol with cannabis seems to occur under conditions of limited deliberation.

Interestingly, habit may serve as a potential intervention target, with habit formation, modification, and substitution playing a crucial role in discontinuing unwanted behaviors or replacing them with more desirable alternatives (Gardner & Rebar, 2019). Multiple behavior change techniques, such as planning, setting behavioral goals, reminders, and self-monitoring, encourage context-dependent repetition, enhance motivation and action control, and contribute to habit formation and change (Gardner & Rebar, 2019; Michie et al., 2013).

The observed direct and indirect past behavior-TPB constructs relationship suggests that, at least for avoiding SAC use, past behavior may influence future behavior through at least three distinct pathways. First, as proposed by Ajzen (2002b), past behavior contributes to the formation of beliefs (i.e., attitudes, subjective norms, self-efficacy, and perceived control) that shape future actions, reinforcing the deliberate pathway—a mechanism supported by our findings. Second, based on the premise that repeated behavior in stable contexts contributes to habit formation, the observed indirect effect suggests that past behavior impacts future behavior via habit formation (Gardner & Rebar, 2019; Ouellette & Wood, 1998), emphasizing its role as an important—though not exclusive—component of this process. However, habit did not fully mediate the past-future behavior relationship, indicating that the frequent enactment of the behavior does not always develop into habits. This suggests a third possible pathway involving additional unmeasured factors, including both deliberative (e.g., descriptive and moral norms; Ajzen, 2020; Manning, 2009) and non-deliberative processes (e.g., implicit attitudes and impulsivity; Hamilton et al., 2020).

Finally, the extended TPB model showed invariance across sex and educational status. While sex differences in the TPB's predictive power for substance-related behaviors have been reported (Cooke et al., 2016; Kyrrestad et al., 2022; Moan & Rise, 2011), our results partially align with Fernández-Calderón et al. (2025), who reported similar model functioning for men and women in models incorporating non-deliberative components in explaining protective behaviors. Moreover, although prior evidence suggests differences in SAC use (Linden-Carmichael et al., 2020) and some TPB components, such as social norms (Carter et al., 2010; Quinn & Fromme, 2011), between college and non-college students, our findings indicate no differences in model performance. To our knowledge, this is the first study to examine TPB invariance in substance-related protective behaviors across educational status. Taken together, these results suggest that interventions based on the TPB model could be equally effective across these sociodemographic groups. However, future studies should replicate these findings in other contexts and populations and further examine their applicability to additional dimensions of diversity (e.g., ethnicity, socioeconomic status). Such analyses would provide a more comprehensive understanding of the generalizability of TPB-based interventions across diverse populations.

Despite the valuable insights provided, this study has several limitations. The use of non-probabilistic sampling limits generalizability, and reliance on self-reported measures may have introduced memory or social desirability bias (Armitage & Conner, 2011). Furthermore, the 3-month lag between measuring intention and behavior may have weakened associations between TPB constructs. Although our results still showed strong predictive power, the model appears to be more explanatory in the short term (Hagger et al., 2023). Finally, habit was assessed using a two-item measure (Fernández-Calderón et al., 2025). Although one of the items used aligns with Gardner et al.'s (2024) recommendation for brief and credible measures of habit strength, the instrument used has been shown to moderate the habit–behavior relationship (Hagger et al., 2023). Employing multi-item measures of habit strength (e.g., Self-Report Habit Index, Verplanken & Orbell, 2003) could provide a more comprehensive assessment of the construct in future studies.

Despite these limitations, our findings highlight that while the TPB is a strong framework for understanding health-promoting behaviors, habit strength—a non-deliberative process—was identified as the primary predictor of SAC avoidance. However, conscious processes still matter, as reflected in the attitude–intention and intention–behavior links. The model's invariance across sex and college status suggests that TPB-based interventions could be broadly applicable across these sociodemographic groups. By highlighting the central role of automatic processes, this study advances theoretical understanding and provides insights for more effective strategies to modify substance-related behaviors.

From a policy perspective, our findings emphasize that while changing attitudes is a valuable pathway for promoting SAC avoidance, interventions may be more effective when complemented with strategies that promote context-dependent repetition of protective behaviors and foster habit formation (i.e., that incorporate non-deliberative processes). Thus, beyond focusing on changing beliefs and increasing knowledge (Steinmetz et al., 2016), policies that integrate habit-formation principles (e.g., cues, reminders, environmental restructuring) into community and campus-based programs may enhance the long-term sustainability of behavior change. For professional practice, integrating motivational components with behavior change techniques such as implementation intentions, action planning, and self-monitoring (Gardner & Rebar, 2019; Michie et al., 2013) may help consolidate protective strategies as automatic routines. To conclude, integrating both reasoned and automatic processes, interventions may achieve greater effectiveness and durability in reducing the risks associated with SAC use.

Author Contribution BVV: conceptualization, methodology, data curation, formal analysis, writing–original draft. APG: methodology, data curation, formal analysis, writing–review and editing. JCM: methodology, data curation, formal analysis, writing–review and editing. FFC: conceptualization, methodology, funding acquisition, investigation, project administration, writing–review and editing.

Funding Funding for open access publishing: Universidad de Huelva/CBUA. This work was funded by the Agencia Estatal de Investigación (Ministerio de Ciencia, Innovación y Universidades, Spain; MICIU/AEI//10.13039/501100011033/) under grant number PID2020-118229RB-I00 granted to Fermín Fernández Calderón. The source of funding did not participate in the design of the study, data collection, analysis, or interpretation, the writing of the article, or in the decision to submit it for publication.

Data Availability The data necessary to reproduce the findings reported are openly available in Open Science Framework at https://osf.io/u79pr/files/osfstorage

Declarations

Ethics Approval and Informed Consent All study protocols were approved by the Regional Committee for Bioethics Research of Andalusia (Regional Ministry of Health, Andalusia, Spain) under code 0283-N-22 and comply with APA ethical standards for human research.

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 (5). Informed consent was obtained from all participants for being included in the study.

Conflict of Interest The authors declare no competing interests.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Ajzen, I. (2002a). Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior 1. *Journal of Applied Social Psychology, 32*(4), 665–683. https://doi.org/10.1111/j.1559-1816.2002.tb00236.x

Ajzen, I. (2002b). Residual effects of past on later behavior: Habituation and reasoned action perspectives. *Personality and Social Psychology Review, 6*(2), 107–122. https://doi.org/10.1207/S15327957PSPR0602_

Ajzen, I. (2006). *Constructing a theory of planned behaviour questionnaire: Conceptual and methodological consideration.* http://www.people.umass.edu/aizen/pdf/tpb.measurement.pdf

Ajzen, I. (2011). The theory of planned behaviour: Reactions and reflections. *Psychology & Health, 26*(9), 1113–1127. https://doi.org/10.1080/08870446.2011.613995

Ajzen, I. (2013). *Theory of planned behaviour questionnaire. Measurement Instrument Database for the Social Science.* Retrieved from www.midss.ie

Ajzen, I. (2020). The theory of planned behavior: Frequently asked questions. *Human Behavior and Emerging Technologies, 2*(4), 314–324. https://doi.org/10.1002/hbe2.195

Ajzen, I., & Sheikh, S. (2013). Action versus inaction: Anticipated affect in the theory of planned behavior. *Journal of Applied Social Psychology, 43*(1), 155–162. https://doi.org/10.1111/j.1559-1816.2012.00989.x

Albarracin, D., Johnson, B. T., Fishbein, M., & Muellerleile, P. A. (2001). Theories of reasoned action and planned behavior as models of condom use: A meta-analysis. *Psychological Bulletin, 127*(1), 142–161. https://doi.org/10.1037/0033-2909.127.1.142

Arbour-Nicitopoulos, K. P., Kwan, M. Y., Lowe, D., Taman, S., & Faulkner, G. E. (2010). Social norms of alcohol, smoking, and marijuana use within a Canadian university setting. *Journal of American College Health, 59*(3), 191–196. https://doi.org/10.1080/07448481.2010.502194

Armitage, C. J., & Conner, M. (2001). Efficacy of the theory of planned behaviour: A meta-analytic review. *British Journal of Social Psychology, 40*(4), 471–499. https://doi.org/10.1348/014466601164939

Brown, D. J., Hagger, M. S., & Hamilton, K. (2020). The mediating role of constructs representing reasoned-action and automatic processes on the past behavior-future behavior relationship. *Social Science & Medicine, 258*, Article 113085. https://doi.org/10.1016/j.socscimed.2020.113085

Carter, A. C., Brandon, K. O., & Goldman, M. S. (2010). The college and noncollege experience: A review of the factors that influence drinking behavior in young adulthood. *Journal of Studies on Alcohol and Drugs, 71*(5), 742–750. https://doi.org/10.15288/jsad.2010.71.742

Collins, R. L., Parks, G. A., & Marlatt, G. A. (1985). Social determinants of alcohol consumption: The effects of social interaction and model status on the self-administration of alcohol. *Journal of Consulting and Clinical Psychology, 53*(2), 189–200. https://doi.org/10.1037/0022-006X.53.2.189

Conner, M., & Sparks, P. (2015). The theory of planned behaviour and the reasoned action approach. In M. Conner & P. Norman (Eds.), *Predicting and changing health behaviour: Research and practice with social cognition models* (pp. 142–188). Open University Press.

Cooke, R., Dahdah, M., Norman, P., & French, D. P. (2016). How well does the theory of planned behaviour predict alcohol consumption? A systematic review and meta-analysis. *Health Psychology Review, 10*(2), 148–167. https://doi.org/10.1080/17437199.2014.947547

Cooke, R., Sniehotta, F., & Schüz, B. (2007). Predicting binge-drinking behaviour using an extended TPB: Examining the impact of anticipated regret and descriptive norms. *Alcohol and Alcoholism, 42*(2), 84–91. https://doi.org/10.1093/alcalc/agl115

IBM Corp. (2016). *IBM SPSS Statistics for Windows (Version 24.0) [Software].*

Cummings, C., Beard, C., Habarth, J. M., Weaver, C., & Haas, A. (2019). Is the sum greater than its parts? Variations in substance-related consequences by conjoint alcohol-marijuana use patterns. *Journal of Psychoactive Drugs, 51*(4), 351–359. https://doi.org/10.1080/02791072.2019.1599473

Davis, A. K., & Rosenberg, H. (2016). Using the theory of planned behavior to predict implementation of harm reduction strategies among MDMA/ecstasy users. *Psychology of Addictive Behaviors, 30*(4), 500–508. https://doi.org/10.1037/adb0000167

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). *Internet, phone, mail, and mixed-mode surveys: The tailored design method*. Wiley & Sons.

Duckworth, J. C., & Lee, C. M. (2019). Associations among simultaneous and co-occurring use of alcohol and marijuana, risky driving, and perceived risk. *Addictive Behaviors, 96*, 39–42. https://doi.org/10.1016/j.addbeh.2019.03.019

Earle, A. M., Napper, L. E., LaBrie, J. W., Brooks-Russell, A., Smith, D. J., & de Rutte, J. (2020). Examining interactions within the theory of planned behavior in the prediction of intentions to engage in cannabis-related driving behaviors. *Journal of American College Health, 68*(4), 374–380. https://doi.org/10.1080/07448481.2018.1557197

Fernández-Calderón, F., Bravo, A. J., Díaz-Batanero, C., Palamar, J. J., & Carmona-Márquez, J. (2022). Alcohol protective behavioral strategies in young Spanish adults in the community: A prospective study of perceived efficacy and social norms. *Psicothema*. https://doi.org/10.7334/psicothema2021.413

Fernández-Calderón, F., Lozano-Rojas, Ó. M., & Sanchez-Garcia, M. (2025). The theory of planned behavior and alcohol protective behavioral strategies: A prospective study examining the role of habit and gender invariance. *Psychology & Health, 40*(7), 1123–1142. https://doi.org/10.1080/08870446.2023.2300029

Gagnon, H., Tessier, S., Côté, J., April, N., & Julien, A. S. (2012). Psychosocial factors and beliefs related to intention to not binge drink among young adults. *Alcohol and Alcoholism, 47*(5), 525–532. https://doi.org/10.1093/alcalc/ags049

Gardner, B., Abraham, C., Lally, P., & de Bruijn, G. J. (2012). Towards parsimony in habit measurement: Testing the convergent and predictive validity of an automaticity subscale of the self-report habit index. *International Journal of Behavioral Nutrition and Physical Activity, 9*(102), 1–12. https://doi.org/10.1186/1479-5868-9-102

Gardner, B., Lally, P., & Rebar, A. L. (2024). Can—and should—automaticity be self-reported using a single item? A secondary analysis of 16 datasets. *Applied Psychology: Health and Well-Being, 16*(4), 2438–2457. https://doi.org/10.1111/aphw.12600

Gardner, B., & Rebar, A. L. (2019). Habit formation and behavior change. *Oxford Research Encyclopedia of Psychology.* Retrieved from https://oxfordre.com/psychology/view/10.1093/acrefore/9780190236557.001.0001/acrefore-9780190236557-e-129

Goodman, L. A. (1961). Snowball sampling. *The Annals of Mathematical Statistics, 32*(1), 148–170. https://doi.org/10.1214/aoms/1177705148

Graupensperger, S., Hultgren, B. A., Fairlie, A. M., Lee, C. M., & Larimer, M. E. (2023). Using alcohol and cannabis as sleep aids: Associations with descriptive norms among college students. *Behavioral Sleep Medicine, 21*(1), 84–96. https://doi.org/10.1080/15402002.2022.2040505

Hagger, M. S., Chan, D. K., Protogerou, C., & Chatzisarantis, N. L. (2016). Using meta-analytic path analysis to test theoretical predictions in health behavior: An illustration based on meta-analyses of the theory of planned behavior. *Preventive Medicine, 89*, 154–161. https://doi.org/10.1016/j.ypmed.2016.05.020

Hagger, M. S., Chatzisarantis, N. L., & Biddle, S. J. (2002). A meta-analytic review of the theories of reasoned action and planned behavior in physical activity: Predictive validity and the contribution of additional variables. *Journal of Sport and Exercise Psychology, 24*(1), 3–32. https://doi.org/10.1123/jsep.24.1.3

Hagger, M. S., Cheung, M. W. L., Ajzen, I., & Hamilton, K. (2022). Perceived behavioral control moderating effects in the theory of planned behavior: A meta-analysis. *Health Psychology, 41*(2), 155–167. https://doi.org/10.1037/hea0001153

Hagger, M. S., & Hamilton, K. (2024). Longitudinal tests of the theory of planned behaviour: A meta-analysis. *European Review of Social Psychology, 35*(1), 198–254. https://doi.org/10.1080/10463283.2023.2225897

Hagger, M. S., Hamilton, K., Phipps, D. J., Protogerou, C., Zhang, C. Q., Girelli, L., Mallia, L., & Lucidi, F. (2023). Effects of habit and intention on behavior: Meta-analysis and test of key moderators. *Motivation Science, 9*(2), 73–94. https://doi.org/10.1037/mot0000294

Hagger, M. S., Lonsdale, A. J., Hein, V., Koka, A., Lintunen, T., Pasi, H., Lindwall, M., Rudolfsson, L., & Chatzisarantis, N. L. (2012). Predicting alcohol consumption and binge drinking in company employees: An application of planned behaviour and self-determination theories. *British Journal of Health Psychology, 17*(2), 379–407. https://doi.org/10.1111/j.2044-8287.2011.02043.x

Hagger, M. S., Polet, J., & Lintunen, T. (2018). The reasoned action approach applied to health behavior: Role of past behavior and tests of some key moderators using meta-analytic structural equation modeling. *Social Science & Medicine, 213*, 85–94. https://doi.org/10.1016/j.socscimed.2018.07.038

Hamilton, K., Gibbs, I., Keech, J. J., & Hagger, M. S. (2020). Reasoned and implicit processes in heavy episodic drinking: An integrated dual-process model. *British Journal of Health Psychology, 25*(1), 189–209. https://doi.org/10.1111/bjhp.12401

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach.* Guilford Press.

Jackson, K. M., Sokolovsky, A. W., Gunn, R. L., & White, H. R. (2020). Consequences of alcohol and marijuana use among college students: Prevalence rates and attributions to substance-specific versus simultaneous use. *Psychology of Addictive Behaviors, 34*(2), 370–381. https://doi.org/10.1037/adb0000545

Kline, R. B. (2005). *Principles and practice of structural equation modeling*. Guilford Press.

Kyrrestad, H., Mabille, G., Adolfsen, F., Koposov, R., & Martinussen, M. (2022). Gender differences in alcohol onset and drinking frequency in adolescents: An application of the theory of planned behavior. *Drugs Education, Prevention and Policy, 29*(1), 21–31. https://doi.org/10.1080/09687637.2020.1865271

La Barbera, F., & Ajzen, I. (2020). Control interactions in the theory of planned behavior: Rethinking the role of subjective norm. *Europe's Journal of Psychology, 16*(3), 401–417. https://doi.org/10.5964/ejop.v16i3.2056

Lee, C. M., Calhoun, B. H., Abdallah, D. A., Blayney, J. A., Schultz, N. R., Brunner, M., & Patrick, M. E. (2022). Simultaneous alcohol and marijuana use among young adults: A scoping review of prevalence, patterns, psychosocial correlates, and consequences. *Alcohol research: current reviews, 42*(1), 8. https://doi.org/10.35946/arcr.v42.1.08

Linden-Carmichael, A. N., Van Doren, N., Masters, L. D., & Lanza, S. T. (2020). Simultaneous alcohol and marijuana use in daily life: Implications for level of use, subjective intoxication, and positive and negative consequences. *Psychology of Addictive Behaviors, 34*(3), 447–453. https://doi.org/10.1037/adb0000556

Manning, M. (2009). The effects of subjective norms on behaviour in the theory of planned behaviour: A meta-analysis. *British Journal of Social Psychology, 48*(4), 649–705. https://doi.org/10.1348/014466608X393136

McEachan, R. R. C., Conner, M., Taylor, N. J., & Lawton, R. J. (2011). Prospective prediction of health-related behaviours with the theory of planned behaviour: A meta-analysis. *Health Psychology Review, 5*(2), 97–144. https://doi.org/10.1080/17437199.2010.521684

Merrill, J. E., & Carey, K. B. (2016). Drinking over the lifespan: Focus on college ages. *Alcohol Research: Current Reviews, 38*(1), 103–114.

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., Eccles, M. P., Cane, J., & Wood, C. E. (2013). The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions. *Annals of Behavioral Medicine, 46*(1), 81–95. https://doi.org/10.1007/s12160-013-9486-6

Moan, I. S., & Rise, J. (2011). Predicting intentions not to "drink and drive" using an extended version of the theory of planned behaviour. *Accident Analysis and Prevention, 43*(4), 1378–1384. https://doi.org/10.1016/j.aap.2011.02.012

Murphy, S., Bright, S. J., & Dear, G. (2021). Could a drug-checking service increase intention to use ecstasy at a festival? *Drug and Alcohol Review, 40*(6), 974–978. https://doi.org/10.1111/dar.13259

Muthén, L.K. & Muthén, B.O. (2015). *Mplus user's guide.* Seventh Edition. Muthén & Muthén

Norman, P. (2011). The theory of planned behavior and binge drinking among undergraduate students: Assessing the impact of habit strength. *Addictive Behaviors, 36*(5), 502–507. https://doi.org/10.1016/j.addbeh.2011.01.025

Ouellette, J. A., & Wood, W. (1998). Habit and intention in everyday life: The multiple processes by which past behavior predicts future behavior. *Psychological Bulletin, 124*(1), 54–74. https://doi.org/10.1037/0033-2909.124.1.54

Patrick, M. E., Terry-McElrath, Y. M., Lee, C. M., & Schulenberg, J. E. (2019). Simultaneous alcohol and marijuana use among underage young adults in the United States. *Addictive Behaviors, 88*, 77–81. https://doi.org/10.1016/j.addbeh.2018.08.015

Pearson, M. R., Protective Strategies Study Team, & Addictions Research Team. (2023). *Marijuana use grid: A brief, comprehensive measure of cannabis use.* Unpublished manuscript.

Quinn, P. D., & Fromme, K. (2011). Alcohol use and related problems among college students and their noncollege peers: The competing roles of personality and peer influence. *Journal of Studies on Alcohol and Drugs, 72*(4), 622–632. https://doi.org/10.15288/jsad.2011.72.622

Rise, J., & Wilhelmson, B. U. (1998). Prediction of adolescents' intention not to drink alcohol: Theory of planned behavior. *American Journal of Health Behavior, 22*(3), 206–217.

Rodríguez-Martos, D. A., Gual, S. A., & Llopis, L. J. (1999). The "standard drink unit" as a simplified record of alcoholic drink consumption and its measurement in Spain. *Medicina Clinica, 112*(12), 446–450.

Sánchez-García, M., Carmona-Márquez, J., Bravo, A. J., & Fernández-Calderón, F. (2024). Spanish adaptation and psychometric properties of the protective behavioral strategies for marijuana scale: The protective behavioral strategies for cannabis scale (S-PBSC). *International Journal of Mental Health and Addiction*. https://doi.org/10.1007/s11469-024-01311-2

Satorra, A., & Bentler, P. M. (2010). Ensuring positiveness of the scaled difference chi-square test statistic. *Psychometrika, 75*(2), 243–248. https://doi.org/10.1007/s11336-009-9135-y

Schulenberg, J. E., & Maggs, J. L. (2002). A developmental perspective on alcohol use and heavy drinking during adolescence and the transition to young adulthood. *Journal of Studies on Alcohol, Supplement*, (14), 54–70. https://doi.org/10.15288/jsas.2002.s14.54

Sheeran, P., Gollwitzer, P. M., & Bargh, J. A. (2013). Nonconscious processes and health. *Health Psychology, 32*(5), 460–473. https://doi.org/10.1037/a0029203

Steinmetz, H., Knappstein, M., Ajzen, I., Schmidt, P., & Kabst, R. (2016). How effective are behavior change interventions based on the theory of planned behavior? *Zeitschrift Für Psychologie, 224*(3), 216–233. https://doi.org/10.1027/2151-2604/a000255

Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior. *Personality and Social Psychology Review, 8*, 220–247. https://doi.org/10.1207/s15327957pspr0803_1

Thompson, K., Holley, M., Sturgess, C., & Leadbeater, B. (2021). Co-use of alcohol and cannabis: Longitudinal associations with mental health outcomes in young adulthood. *International Journal of Environmental Research and Public Health, 18*(7), Article 3652. https://doi.org/10.3390/ijerph18073652

Tomko, R. L., Gex, K. S., Davis, C. N., Schick, M. R., Kirkland, A. E., Squeglia, L. M., Flanagan, J. C., Gray, K. M., & McRae-Clark, A. L. (2023). Sex and gender differences in simultaneous alcohol and cannabis use: A narrative review. *Current Addiction Reports, 10*(4), 628–637. https://doi.org/10.1007/s40429-023-00513-3

Topa, G., & Moriano, J. A. (2010). Theory of planned behavior and smoking: Meta-analysis and SEM model. *Substance Abuse and Rehabilitation, 1*, 23–33. https://doi.org/10.2147/SAR.S15168

Treloar, H., Martens, M. P., & McCarthy, D. M. (2015). The protective behavioral strategies scale-20: Improved content validity of the serious harm reduction subscale. *Psychological Assessment, 27*(1), 340–346. https://doi.org/10.1037/pas0000071

United Nations Office on Drugs and Crime (2023). *World Drug Report 2023.* United Nations Office on Drugs and Crime. Retrieved from: https://www.unodc.org/res/WDR-2023/WDR23_Exsum_fin_DP.pdf

Verplanken, B., & Orbell, S. (2003). Reflections on past behavior: A self-report index of habit strength. *Journal of Applied Social Psychology, 33*(6), 1313–1330. https://doi.org/10.1111/j.1559-1816.2003.tb01951.x

Vervaeke, H. K., Korf, D. J., Benschop, A., & van den Brink, W. (2007). How to find future ecstasy-users: Targeted and snowball sampling in an ethically sensitive context. *Addictive Behaviors, 32*(8), 1705–1713. https://doi.org/10.1016/j.addbeh.2006.11.008

Watters, J. K., & Biernacki, P. (1989). Targeted sampling: Options for the study of hidden populations. *Social Problems, 36*(4), 416–430. https://doi.org/10.2307/800824

White, H. R., Kilmer, J. R., Fossos-Wong, N., Hayes, K., Sokolovsky, A. W., & Jackson, K. M. (2019). Simultaneous alcohol and marijuana use among college students: Patterns, correlates, norms, and consequences. *Alcoholism, Clinical and Experimental Research, 43*(7), 1545–1555. https://doi.org/10.1111/acer.14072

World Health Organization (2018). *Global status report on alcohol and health 2018.* World Health Organization. Retrieved from: https://www.drugsandalcohol.ie/34429/1/action-planon-alcohol_first-draft-final_formatted.pdf

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.