Beyond Dichotomies: Identifying Alcohol and Cannabis Co-use Patterns Across Gender Through Tests of Predictive and Explanatory Similarity in Emerging Adults

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Abstract

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Emerging adulthood is a developmental period marked by increased risky behaviours, including alcohol and cannabis co-use (AC co-use). AC co-use is associated with more health and occupation-related negative consequences compared to the isolated use of any one of these substances. Several studies examine co-use as a dichotomy (i.e., whether someone co-uses or not), which limits our understanding of the heterogeneity of co-use profiles and its impact on negative consequences. Furthermore, given emerging evidence supporting gender differences in negative consequences experienced specific to AC co-use, it is critical to consider how gender may influence the nature of emerging adult co-use profiles, determinants, and consequences. The present study addresses these limitations by pursuing three core objectives: (i) identify single and co-use patterns across gender; (ii) examine personality factors (i.e., impulsivity) as a predictor of patterns; (iii) link patterns with negative consequences to measure risk. This online study included 468 first-year undergraduate participants who completed measures of alcohol and cannabis quantity and frequency of use, impulsivity, and negative consequences for both alcohol and cannabis use. Latent profile analyses revealed four AC co-use patterns. Two were identical across gender: Profile 1 – *Heavy Alcohol Single Use and Elevated Alcohol Co-Use* and Profile 2 – *Primarily Moderate Alcohol Single Use*. Profile 4 (*Light AC Single Use and Elevated Alcohol Co-Use*) was also highly similar across genders. However, gender-diverse individuals and women tended to use and co-use cannabis to a greater extent than men. In contrast, Profile 3 differed in women relative to men and gender-diverse individuals. Indeed, women in this profile primarily heavily use alcohol on co-use days (*Primarily Heavy Alcohol Co-Users*); men and gender-diverse individuals displayed a more problematic pattern (*Heavy Cannabis Single Use and Elevated Alcohol Co-Use*) involving heavy use and co-use of cannabis, coupled with a heavy co-use of alcohol. Interestingly, however, predictions and outcomes generalized across genders, suggesting that despite these differences in patterns, these profiles seem to capture similar psychological mechanisms. Consistent with our hypotheses, two facets of impulsivity (i.e., negative urgency and sensation-seeking) predicted risky AC co-use patterns. However, another facet (positive urgency) was related to less problematic AC co-use patterns. More negative consequences were associated with the heaviest co-use pattern (i.e., Profile 3). Unexpectedly, Profile 4 (also displaying high AC co-use) was associated with a similarly high level of negative consequences. Profile 1 (dominated by alcohol use and co-use) also had a similar level of alcohol-related negative consequences as Profiles 3 and 4. Our findings add meaningful implications and improve refined measurement of AC co-use. Furthermore, this study has contributed to risk model etiology which will further the literature and have clinical implications.

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Introduction

Emerging adulthood – often defined as the developmental period between 18 and 25 years old (Arnett, 2000) – is associated with high rates of alcohol and cannabis co-use (AC co-use) that are unparallel with any other life stage (Terry-McElrath & Patrick, 2018). AC co-use prevalence estimates (i.e., the number of emerging adults who have reported any instance of AC co-use over the past year) have doubled between 2002 and 2018 (McCabe et al., 2021), increasing from an estimated 1.8 million to 2.6 million emerging adults. Annual prevalence rates of AC co-use rates range from 22% to 30%, with the highest rates in younger emerging adults (Terry-McElrath & Patrick, 2018). This is especially troubling as AC co-use has been linked to more negative consequences (e.g., poor occupational functioning, relationship difficulties, health concerns) relative to using only alcohol (Yurasek et al., 2017; Jackson et al., 2020) or cannabis (Linden-Carmichael et al., 2020). Consensus about differences in risk remains mixed, as other studies found no significant differences in the negative consequences experienced between AC co-use and alcohol alone (Mallett et al., 2019; Sokovosky et al., 2020) or cannabis alone (Mallett et al., 2019). Given contradictory findings, more work is needed to disentangle the nature and level of risk AC co-use poses.

Several challenges have limited advancements in AC co-use research. First, substance co-use has been ill-defined, and the term is inconsistently used (Lee et al., 2022). Second, most AC co-use studies have been limited to dichotomous measures of co-use such as co-user or non-user (person-level) or co-use day versus no co-use (event level) (e.g., Ito et al., 2021). In most studies, though temporally variable, co-use requires at least one instance of AC co-use within a specific period of time (e.g., past week/month/lifetime). Dichotomous measures miss out on the breadth of co-use patterns (i.e., the different ways AC co-use may occur) and thus impede our ability to discern if specific AC co-use patterns are riskier than others. Without a shared operationalization of AC co-use and a lack of implementation of variables that capture the full range of co-use patterns, it has been difficult to advance risk models. This study aims to quantify the complexity of AC co-use among emerging adults and provide an empirical test of a theoretically rooted risk model of co-use.

Defining Alcohol and Cannabis Co-Use

Beyond the use of various labels to refer to AC co-use (e.g., dual use, sequential use, co-administration, or cross-fading; Tucker et al., 2021; Lee et al., 2022), AC co-use has also been inconsistently used across the literature, with variants including (a) using both substances but on different days, (b) using alcohol and cannabis within the same day but not at the same time, and (c) using both substances simultaneously for overlapping effects. Thus, some have highlighted the need for a common definition of AC co-se (Lee et al., 2022). To date, the most consistent operationalization of AC co-use points to either (Yurasek et al., 2017): (1) simultaneous use (i.e., both substances are used with overlapping effects and/or within a specific time period) and (2) concurrent use (i.e., both substances are used without overlapping effects and/or outside of a specific time period).

Different interpretations of AC co-use have led to a variety of timeframes to capture AC co-use, from large-scale timelines like past year occurrences (e.g., Stamates et al., 2022) to small-scale timelines focused on the past week or day (e.g., Sokolovosky et al., 2020). The former approach is problematic as evidence suggests examining co-use at a daily level may be the most precise and informative way to understand co-use instead and its immediate consequences. For instance, in a study examining changes in AC co-use behaviours among college students, alcohol intake increased on days in which marijuana was also used (Ito et al., 2021). However, this association weakened significantly when considered at the annual level. As such, this study relies on a fine-grained daily timeframe to study AC co-use, following recommendations from Lee et al. (2022).

Patterns of Alcohol and Cannabis Co-Use – Beyond Dichotomies

Regardless of the co-use definition used it any given study, researchers often default to simplistic dichotomous scoring to separate co-users from non-co-users (person-level) or co-use occasions from a non-co-use occasions (event-level) (e.g., Patrick et al., 2018; Mallett et al., 2019; Stamates et al., 2022). For greater prevision, AC co-use research needs to move beyond such dichotomies by adopting metrics similar to those currently used in single substance use research, which focus on quantity and frequency rather than solely on presence or absence of use. In contrast to alcohol (e.g., standardized drinks), complexity in measuring cannabis makes measurement AC co-use difficult to measure AC co-use due to a lack of standardized methods to measure cannabis intake accurately (Lee et al., 2022). For this reason, though some studies of AC co-use have started to adopt more accurate alcohol use metrics (e.g., quantity, frequency), these studies still rely on weaker dichotomic measures of cannabis intake (e.g., Waddell et al., 2021; Stamates et al., 2022). This lack of precision makes it hard to properly understand the complete heterogeneity of co-use patterns (e.g., an individual who uses alcohol heavily and co-uses frequently versus someone who uses cannabis heavily and co-uses infrequently; Subbaraman & Kerr, 2015).

Studies that went beyond a dichotomy found those who reported more frequent co-use or heavier quantities of co-used substances had the worst occupational outcomes and mental health symptoms when compared to other co-use groups (Green et al., 2016; Thompson et al., 2021). Furthermore, empirical evidence suggests on days when an individual co-uses, the quantities of substances used increase relative to days they only one of the substances (Subbaraman & Kerr, 2015; Ito et al., 2021; Boyle et al., 2024). Wardell et al. (2024) were the first to examine the role of both cannabis and alcohol quantities (rather than treating cannabis use as a dichotomous variable) on negative consequences of cannabis and alcohol use and co-use among emerging adults. Cannabis quantity was found to weaken the association between lighter drinking and fewer negative consequences on simultaneous use days, but did not modify negative consequences among heavy drinkers (Wardell et al., 2024). These novel results highlight the need for more work to unpack the full breadth of co-use patterns in high-risk populations (i.e., groups that tend to AC co-use), such as emerging adults, to properly target key intervention areas (e.g., Subbaraman & Kerr, 2015; Linden-Carmichael et al., 2020; Lee et al., 2022).

Gender Differences in Alcohol and Cannabis Co-Use

Despite clear differences (sex is a biological construct whereas gender is a social construct), most psychological, most psychological research has incorrectly conflated sex and gender. More precisely, sex is assigned at birth based on anatomy, hormones, and genes (Johnson et al., 2011), and is often incorrectly operationalized according to a male-female dichotomy even though other possibilities (e.g., intersex) exist. In contrast, gender is a socially constructed identity that describes how individuals see themselves along a men-women continuum or outside of that continuum (Johnson et al., 2011) Though both are known to play a role in the initiation, development, and maintenance of substance use related consequences, gender appears to be a particularly critical social determinant of physical and mental health (i.e., cis-gender women experience more disadvantages relative to cis-gender men; Phillips, 2005). Moreover, gender-diverse individuals (i.e., present and/or identify outside the gender binary of man or woman) increase their susceptibility to physical and mental health difficulties, exceeding those of cis-gender men and women (Henderson et al., 2022). The present study thus considers participants' gender identity (i.e., men, women, gender-diverse) as a core factor likely to influence results.

Sex and gender differences in substance use have been well-documented. Men are more likely to use alcohol and cannabis more heavily than women and report higher rates of substance use disorders (McHugh et al., 2018). Several studies suggest men (Subbaraman & Kerr, 2015) or males (Lipperman-Kreda et al., 2018; Patrick et al., 2019) engage more frequently and intensely in AC co-use than women and females. For instance, a study examining co-use patterns over time found that males made up 75% of the "increasing marijuana and moderate alcohol use" profile, which was the profile linked to the worse outcomes (Green et al., 2016). However, evidence is less clear regarding whether and how sex and gender influence the consequences of specific use and co-use profiles. Still, some studies suggest that AC co-use is more problematic for women, given that more consequences were found in this gender group (e.g., Parks et al., 2012). A co-use study (Ito et al., 2021) also found that cannabis use predicted a slightly larger increase in alcohol consumption in women relative to men. Likewise, a third study found more negative consequences on co-use days relative to cannabis-only days for females, but not for males (Linden-Carmichael et al., 2020). In contrast, other studies have found no sex differences in AC co-use (Wardell et al., 2024). However, in most of these studies, AC co-use was dichotomized and inconsistently operationalized, reinforcing the need for additional research relying on improved methodologies.

Beyond these previous studies focused on sex and/or gender dichotomies, emerging substance use research has gone beyond the dichotomy of the cis-gender binary by considering gender-diverse individuals. Consistent with (1) the minority stress model (which posits those in minority groups are at heightened risk for experiencing stress due to stigma and discrimination; Meyer, 2003) and (2) the self-medication hypothesis (which theorizes individuals utilize substances to deal with stress; Khantzian, 1997), show that gender-diverse individuals (e.g., *trans* or *non-binary*) tend to be at higher risk of substance misuse when compared to their cis-gender peers (Connolly & Gilchrist, 2020). This emerging research, however, remains fairly limited in relation to AC co-use. However, some new evidence suggests gender-diverse individuals who were female at birth report comparable levels of AC co-use to queer cis-gender women (Watson et al., 2020). Another study found that drinking and cannabis use quantity differed as a function of the gender of their use partners (Dyar et al., 2024). As evidence remains preliminary, gender-diverse individuals are an important sub-population to capture within our analyses.

Impulsivity and Alcohol and Cannabis Co-Use

Impulsivity, a personality domain defined by disinhibited action with little future-oriented thinking and possible consequences, has been implicated as a key risk factor in the initiation and maintenance of alcohol and cannabis use (Moeller et al., 2001; Waddell et al., 2022). The first key model that helps inform understanding of impulsivity is the two-dimensional model proposed by Dawe, Gullo and Loxton (2004). In this two-dimensional model, two key traits are identified that link impulsivity to substance misuse (Dawe et al., 2004): (1) reward drive (i.e., sensitivity to rewarding stimuli) and (2) rash impulsiveness (i.e., acting without thought for future consequences). According to this model, individuals who are high in impulsivity are at increased risk of engaging in substance misuse and maintaining problematic substance use despite negative consequences via two complementary pathways. First, individuals who are predisposed to heightened reward sensitivity are more likely to use alcohol and cannabis. In turn, this may create a strong conditioned response to substances with continued use. Second, when deciding to partake in substance use, individuals high in rash impulsiveness are less likely to recall times in which substance misuse had impacted them negatively. Evidence supporting this model has been found among samples of emerging adults who use alcohol only (e.g., Gullo et al., 2010) and cannabis only (Papinczak et al., 2018).

Whiteside and Lynman (2001) proposed a more comprehensive operationalization of impulsivity as encompassing five distinct facets: (1) sensation-seeking (SS; the tendency to seek excitement and adventure); (2) positive urgency (PU; the tendency to respond impulsively when in a positive mood); (3) negative urgency (NU; the tendency to respond impulsively when in a negative mood); (4) (lack of) premeditation (PM; the tendency to act without considering potential consequences); and (5) (lack of) perseverance (PS; the inability to remain on task until completion and avoid boredom). Many of these facets have been linked to behavioural impairments in binge drinkers and recreational cannabis users (Moreno et al., 2012), and increased alcohol (Magid et al., 2007) and cannabis consequences (Hayaki et al., 2011). Among the facets, SS is the facet most consistently associated with co-use (e.g., Linden-Carmichael et al., 2019; Stamates et al., 2022; Waddell et al., 2022). Importantly, Stamates et al. (2022) found that individuals with high scores on SS, NU, and PU were the most likely to engage in AC co-use, had the highest amount of past-year substance use, and reported more negative consequences of alcohol use. Moreover, their analyses showed that SS was the only facet that significantly predicted recent AC co-use relative to alcohol only use. However, evidence specifically linking AC co-use to the urgency facets remains mixed. In one study, greater NU was linked to an increased quantity of alcohol and cannabis use on co-use days (Daros et al., 2022), whereas another study found that NU was the facet least predictive of co-use (e.g., Waddell et al., 2021). Though considerable evidence suggests certain impulsivity facets may be associated with a higher risk of adverse co-use outcomes, which one confers the most risk remains unclear.

Negative Consequences and AC Co-Use

Negative consequences have long been used as a metric of problematic alcohol and cannabis use (Saunders et al., 1993; Adamson et al., 2010; Saitz et al., 2021; Ruberu et al., 2022). Examples include cognitive deficits, development of dependency, time needed to recover from substance use, and engagement in risky situations. A study by Stamates et al. (2022) found the group that was most likely to co-use cannabis and alcohol also reported the most negative consequences related to alcohol use. Furthermore, cannabis use is associated with consuming more alcohol among those experiencing less negative alcohol consequences, relative to those with more (Ito et al., 2021). Together these two studies provide preliminary evidence that co-use may increase one's risk of experiencing negative consequences resulting from substance use, though the nature of this risk remains unclear. Moreover, both studies are limited by either a dichotomous definition of AC co-use (Stamates et al., 2022) or by a lack of consideration of cannabis-related consequences (Ito et al., 2021). The present study addresses both limitations.

The Current Study

AC Co-Use Operationalization

For the current study, we operationalized AC co-use as same-day use which is another term under the co-use umbrella. Same-day use is defined as any day that has both cannabis and alcohol, regardless of whether they were used at the same time or not. This is based on recommendations in a review by Lee et al. (2022) regarding simultaneous AC co-use in emerging adults. They posit that future co-use studies should clearly distinguish how they define co-use to mitigate confusion and misconstrue findings. For example, the authors point out that "simultaneous alcohol and marijuana use" (SAM use; AC co-use) should only be reserved for scenarios in which researchers are certain their measures capture the use of alcohol and cannabis use at the same time. As our measure of AC co-use cannot distinguish between someone who co-used simultaneously or separately (i.e., at different times of the day), we maintain a conservative definition to tease apart same-day AC co-use versus no same-day use.

Study Aims and Hypotheses

This study pursues three main objectives. First, it seeks to identify the nature of the profiles that best capture the heterogeneity of AC single use and co-use among a sample of emerging adults and to document whether and how these profiles differ as a function of gender (cis-gender men, cis-gender women, and gender-diverse). These profiles will be identified based on a comprehensive operationalization of AC single use and co-use encompassing four composite scores: (1) alcohol use on alcohol only days, (2) cannabis use on cannabis only days, (3) alcohol use on co-use days, and (4) cannabis use on cannabis-only days. Second, it seeks to assess the role of impulsivity facets as an individual-level predictor of profile membership and to test whether these predictions differ as a function of gender. We hypothesize that the NU, PU, and SS facets will all be significant predictors of membership in profiles characterized by a more problematic use pattern (higher level of use and co-use), with SS being the strongest predictor of the three. Given the mixed literature on gender differences, we leave as an open research question whether and how these predictions will differ across genders. Third, it seeks to identify which profiles will be associated with the most negative consequences, and whether these consequences will differ across gender. In terms of outcomes, we hypothesize that profiles displaying higher levels of AC co-use will report the most negative consequences. Once again, due to a lack of research guidance, we leave hypotheses specific to gender differences across outcomes open.

Method

Participants

Participants were recruited as part of a larger online longitudinal study examining alcohol use among undergraduate students. All participants were first year students at Concordia University, an English-speaking post-secondary educational institution, in Montreal, Quebec, Canada. To be eligible, participants had to be in their first year, 18-25 years old, and speak English fluently. Surveys were administered in English. A total of 468 participants (M_{age}=20.14, *SD*=1.71) completed the questionnaires, including 126 (26.9%) who identified as cis-gender men, 302 (64.5%) who identified as cis-gender women, and 40 (8.5%) who identified as gender-diverse (e.g., *trans, non-binary*). One hundred and eighty participants (38.4%) identified as a visible minority based on the definition used by the Canadian Employment Equity Act (Government of Canada, 2024) which states "visible minorities" are "persons, other than Aboriginal peoples who are non-white in colour." Five participants (1.07%) identified as Indigenous. Two participants (0.4%) did not report their ethnicity. The remaining 60.49% identified as Caucasian/White.

Procedure

Recruitment was done via online advertisements and flyers around campus. Measures were completed during the Winter 2023 semester. Participants received the link to the surveys through email and access was available for two weeks. Qualtrics XM Software housed all measures for the study. Participants received a $20 gift card as compensation for their time. This study was approved by the research ethics committee of the last author's institution.

Measures

Timeline Follow Back (TLFB; Sobell & Sobell, 1992). The TLFB is a structured calendar-assisted self-report measure in which participants are asked to indicate the quantity of their daily use of alcohol and cannabis for a set amount of time (ranging from the past week to the past year). For this study, we utilized a two-week time frame. With the use of aids (see Appendix A for the visual infographics), participants were asked to report the quantity of alcohol (in standard number of drinks, ranging from 0 to 10 or more drinks) and cannabis (in grams, ranging from 0 grams to 6 or more grams) for each day, for the past 14 days. If a person reported use of both substances on a particular day, that day was considered a co-use day. Quantity scores were calculated using the average number of standard drinks or grams specific to the category (i.e., alcohol only day, cannabis only day, co-use day). For frequency scores, the number of days corresponding to each category (i.e., alcohol only day, cannabis only day, co-use day) was also calculated. Composite scores were obtained by multiplying the numbers of days corresponding to each day category times the average quantity used for that category. Four composite scores reflecting total alcohol/cannabis use were calculated for the current study, these included: (1) alcohol use (total number of standard drinks) on alcohol only days, (2) cannabis use (total number of grams) on cannabis only days, (3) alcohol use (total number of standard drinks) on co-use days, and (4) cannabis use (total number of grams) on co-use days. The psychometric properties of the TLFB for measuring alcohol and cannabis use have been well-supported (Robinson et al., 2014).

Alcohol Use Disorder Identification Test (AUDIT; Saunders et al., 1993). The AUDIT is a 10-item self-report questionnaire assessing hazardous alcohol use consequences. This measure screens for negative consequences related to alcohol use based on frequency and quantity of use, alcohol-related problems, and alcohol use disorder symptoms. In the current study, the first three items related to frequency and quantity were excluded given redundancy with the TLFB, leaving 7 items assessing alcohol-related negative consequences remained (α=.812; e.g., "How often during the past 6 months have you failed to do what was normally expected of you because of drinking?"), for a total score ranging from 0 to 28. A higher score indicates more negative consequences related to alcohol use. For each participant, a factor score for the AUDIT was extracted from preliminary factor analyses. The AUDIT has demonstrated satisfactory scale score reliability among adult and emerging adult populations such as university students (de Meneses-Gaya et al., 2009; Sriken et al., 2022)

Cannabis Use Disorder Identification Test-Revised (CUDIT-R; Adamson et al., 2010). The CUDIT-R is an 8-item self-report questionnaire assessing hazardous negative cannabis use consequences. The predecessor of this measure, the CUDIT, was an adapted version of the AUDIT specific to cannabis use (Adamson & Sellman, 2003). This measure screened for negative consequences of cannabis use based on cannabis frequency and quantity, cannabis-related problems, and cannabis use disorder symptoms. In this study, the first item, (which was related to frequency and quantity) was removed to limit redundancy with the TLFB, leaving 7 items (α=.826; e.g., “How often during the past 6 months have you had a problem with your memory or concentration after using cannabis?”), for a total score ranging from 0 to 28. A higher score indicates more negative consequences related to cannabis use. For each participant, a factor score for the CUDIT-R was extracted from preliminary factor analyses. The CUDIT-R has demonstrated concurrent validity and satisfactory scale score reliability in adult and emerging adult populations (Loflin et al., 2018; Schultz et al., 2019).

UPPS-P Impulsive Behaviour Scale (UPPS-P; Whiteside & Lynman, 2001). The UPPS-P is a 59-item self-report questionnaire assessing the five facets of impulsivity. Responses ranged from 1 (i.e., Agree Strongly) to 4 (i.e., Disagree Strongly). Scores on each facet were calculated respectively: SS ranges from 12-60, NU ranges from 12-60, PU ranges from 14-70, PM ranges from 11-55, and PS ranges from 10-50. SS had 12 items (e.g., “I quite enjoy taking risks.”), NU had 12 items (e.g., “When I feel rejected, I will often say things that I later regret.”), PU had 14 items (e.g., “I tend to act without thinking when I am really excited.”), PM had 11 items (e.g., “I tend to value and follow a rational, ‘sensible’ approach to things.”), and PS had 10 items (e.g., “I concentrate easily.”). Higher scores indicated more impulsivity. Relative to the short version of the UPPS-P, the original and longer UPPS-P offer more precision in measurement on each facet (Lozano et al., 2018). For each participant, factor scores for all five facets were extracted from preliminary factor analyses. Considerable evidence supports the psychometric properties (i.e., reliability, validity) of the UPPS-P (Lozano et al., 2018).

Analyses

Preliminary Analyses

Descriptive statistics and reliability are reported in Table 1. A preliminary confirmatory factor analysis (CFA) model was estimated to verify the psychometric properties of all measures used in this study. This model was estimated using Mplus 8.11 (Muthén & Muthén, 2017) and the robust Weighted Least Square Mean and Variance adjusted estimator (WSLMV). This CFA supported the factor structure and composite reliability of all predictors and outcomes: (a) SS (ω=.900); (b) NU (ω=.914); (c) PU (ω=.965); (d) PM (ω=.892); (e) PS (ω=.862); (f) AUDIT (ω=.933); (h) CUDIT (ω=.933). From this model, the factor scores were extracted for all covariates in standardized units with a grand mean of 0 and a standard deviation of 1. Factor scores preserve the measurement structure of these preliminary analyses (e.g., invariance; Morin et al., 2016) and provide a partial correction for unreliability (Skrondal & Laake, 2001).

Latent Profile Analyses

All of our main analyses were conducted using Mplus 8.11 (Muthén & Muthén, 2017) and the Maximum Likelihood Robust estimator (MLR). Latent profile analyses (LPA) were first used to identify the profiles of AC co-use and single use identified in each of our three gender-specific samples. LPA solutions including one to eight profiles were thus estimated separately for each gender group using the four use composite scores while the means of these indicators were allowed to vary across profiles (Morin & Litalien, 2019; Peugh & Fan, 2013). Although there are advantages to the free estimation of the variance of the indicators across profiles (Peugh & Fan, 2013), these more complex models resulted in important convergence problems in this study (e.g., non-convergence, improper parameter estimates), suggesting overparameterization. When this happens, recommendations are to fall back on simpler models in which these variance parameters are set to equality across profiles (Morin & Litalien, 2019). All models were estimated using 5000 random starts, 1000 iterations, 1000 second optimizations, and 100 final optimizations (Hipp & Bauer, 2006).

To evaluate the optimal number of profiles present in each gender group, we considered the statistical adequacy, heuristic interpretation, and theoretical consistency of each solution (Marsh et al., 2009; Morin & Litalien, 2019). Several statistical indicators were also used to guide this decision. Lower values on the Akaïke Information Criterion (AIC), consistent AIC (CAIC), Bayesian Information Criterion (BIC), and sample-size Adjusted BIC (ABIC) suggest that a solution with one fewer profiles should be retained. Non-significant *p* values for the adjusted Lo, Mendell and Rubin's (2001) Likelihood Ratio Test (aLMR) and Bootstrap Likelihood Ratio Test (BLRT) suggest the solution with one fewer profile ($1-k$, k= number of profiles in the model) should be retained instead of the solution being tested presently. Simulation studies indicate that BIC, CAIC, ABIC, and BLRT provide useful information for model fit, while AIC and aLMR do not (e.g., Morin & Litalien, 2019). Although we report AIC and aLMR for transparency purposes, they are not used to guide our decision-making process. In situations where indicators fail to converge on a specific solution, we can use graphical displays (i.e., elbow plot) to identify an elbow point, where the decrease in value of statistical indicators plateaus with an additional profile (Morin & Litalien, 2019). We also report entropy for a descriptive indication of classification accuracy (ranging from 0 to 1, with higher values suggesting more accuracy) but we do not use this metric to guide our decision.

Tests of Profile Similarity

After selecting the optimal LPA solutions in each gender group, assuming that each solution converged on the same number of profiles, all three solutions were combined into a single LPA model of configural similarity. This model was then used to detect similarities and differences in LPA solutions across the three gender groups using sequential tests of profile similarity (Morin et al., 2016): (i) configural similarity (same number of profiles); (ii) structural similarity (same within-profile means, resulting in profiles with the same shape); (iii) dispersion similarity (same within-profile variance, resulting in similar levels of within-profile variability); (iv) distributional similarity (same profile size). Similarity is supported when two or three out of the CAIC, BIC, and ABIC are lower in a model relative to the previous one (Morin et al., 2016).

Predictive Similarity

After selecting the most similar LPA solution from the tests of similarity, the factor scores of the predictors (i.e., the five facets of impulsivity) were added to the model through a multinomial logistic regression. Two models were contrasted (Morin et al., 2016): (1) a model in which the predictors' effects were freely estimated across genders and (2) a model in which predictors were constrained to equivalence (i.e., predictive similarity).

Explanatory Similarity

Outcomes (i.e., negative consequences) were included in the most similar unconditional LPA solution (Morin et al., 2016). We estimated two models (Morin et al., 2016): (1) a model in which the outcomes were freely estimated across gender groups and (2) a model in which outcomes were constrained to be equivalent across gender groups (i.e., explanatory similarity). The statistical significance of mean differences in outcome levels between profiles was tested in a single step using the multivariate delta method (Raykov & Marcoulides, 2004), implemented in Mplus via the MODEL CONSTRAINT function.

Results

LPA Solutions and Tests of Profile Similarity

The results of the LPA are reported in Table 2 and graphically displayed in Figure 1. The BIC, CAIC, ABIC, and BLRT did not converge on a solution in all three groups (i.e., statistical indicators suggested to keep adding profiles without reaching a minimum). Elbow plots were thus examined (see Figure 1). These plots seemed to reach a rough plateau around four profiles for all three groups. Solutions including three to five profiles were thus more thoroughly inspected. This inspection revealed a high level of similarity in the nature of the profiles across genders, providing preliminary evidence of configural similarity. These results also revealed that adding a fourth profile resulted in the estimation of a meaningfully distinct profile in all groups. In contrast, adding a fifth profile resulted in a very small profile (n=1) with an extreme shape. Thus, we retained the four-profile solution for all genders.

The results from the tests of profile similarity conducted on this solution are reported in Table 3. Although these results failed to support the structural similarity of the solution (higher CAIC, BIC, and ABIC relative to the model of configural similarity), they supported a model of partial structural similarity (lower CAIC and BIC relative to the model of configural similarity) in which some equality constraints were relaxed in Profiles 3 and 4 across genders (these differences are discussed in the next paragraph). Interestingly, despite these differences, the global shape of all profiles remained very similar across genders. From this model, the next model of dispersion similarity (higher CAIC and BIC relative to the model of partial structural similarity model) was rejected, suggesting different levels of within-profile variability across genders. Finally, the last model of distributional similarity was supported (lower CAIC, BIC, and

ABIC relative to the model of partial structural similarity), revealing that the sizes of the profiles was similar across genders.

The results from the final model of distributional similarity are illustrated in Figure 2, and parameter estimates are reported in Table 4. This solution has an excellent classification accuracy (100%), suggesting that it could easily be used to identify participants for intervention purposes. Profile 1 and 2 are identical across all three groups. Profile 1 represents individuals who use very little cannabis but who use alcohol heavily on alcohol-only and co-use days. This *Heavy Alcohol Single Use and Elevated Alcohol Co-Use* profile represented 5.15% of the sample across genders. Profile 2, which represents individuals who moderately use alcohol primarily on its own, report very little co-use days or cannabis use. This *Primarily Moderate Alcohol Single Use* profile represented 91.96% of the sample across genders.

In Profile 3, scores on the first indicator (alcohol only use) were identically low across gender, whereas scores on two of the other indicators (cannabis use on cannabis only days and on co-use days) were also identical and respectively very high and high among men and gender-diverse individuals who only differed from one another in terms of their levels of alcohol use on co-use days (high among men and very high among gender-diverse individuals). In contrast, this profile was primarily characterized by very high levels of alcohol use on co-use days. More precisely, this profile seemed to represent men and gender-diverse individuals who display *Heavy Cannabis Single Use and Elevated Alcohol Co-Use*. In contrast, it describes females who are *Primarily Heavy Alcohol Co-Users*. This profile represented 1.11% of the sample across gender.

Finally, Profile 4 had a similar shape across all genders and was identical across women and gender-diverse individuals. Across all genders, these individuals used very little alcohol on its own (this indicator was identical across all genders) but used it more heavily on co-use days (this indicator is slightly lower among men than women and gender-diverse individuals). Whereas men corresponding to this profile u report using very little cannabis, women and gender-diverse individuals report a moderately high (and identical) level of cannabis use on cannabis only days and on co-use days. This *Light AC Single Use and Elevated Alcohol Co-Use* profile represented 1.78% of the sample across genders.

Predictors of Profile Membership

The results from the alternative predictive model are reported in Tables 3 (model fit) and 5 (parameter estimates) and support the model of predictive similarity (lowest CAIC and BIC). These results suggest the relations between the predictors (i.e., the five facets of impulsivity) and profiles are the same across genders. More specifically, these results show that NU and SS were associated with a higher likelihood of membership into Profile 3 (*Heavy Cannabis Single Use and Elevated Alcohol Co-Use // Primarily Heavy Alcohol Co-Users*) relative to Profiles 2 (*Primarily Moderate Alcohol Single Use*) and 4 (*Light AC Single Use and Elevated Alcohol Co-Use)*, whereas PU had opposite associations (increasing the likelihood of membership into Profiles 2 and 4 relative to 3). NU was also associated with a higher likelihood of membership into Profile 3 (*Heavy Cannabis Single Use and Elevated Alcohol Co-Use // Primarily Heavy Alcohol Co-Users*) relative to Profile 1, whereas SS was also associated with a higher likelihood of membership into Profile 1 (*Heavy Alcohol Single Use and Elevated Alcohol Co-Use*) relative to Profile 2 (*Primarily Moderate Alcohol Single Use*).

Outcomes of Profile Membership

The results from the alternative outcomes models are reported in reported in Tables 3 (model fit) and 6 (results). These results support the model of explanatory similarity (lowest

CAIC, BIC, and ABIC), thus suggesting associations between profiles and outcomes are consistent across genders. These results show that Profile 1 (*Heavy Alcohol Single Use and Elevated Alcohol Co-Use)* experienced significantly more alcohol and cannabis use negative consequences than Profile 2 (*Primarily Moderate Alcohol Single Use*) but lower negative cannabis consequences than Profile 4 (*Light AC Single Use and Elevated Alcohol Co-Use)*. Profile 2 (*Primarily Moderate Alcohol Single Use*) has significantly fewer negative consequences for alcohol and cannabis use than Profiles 3 (*Heavy Cannabis Single Use and Elevated Alcohol Co-Use // Primarily Heavy Alcohol Co-Users*) and 4 (*Light AC Single Use and Elevated Alcohol Co-Use)*, which did not significantly differ from each other on either outcome.

Discussion

Our study aimed to identify high-risk AC co-use profiles amongst an emerging adult sample across genders and link them to a proposed risk model of impulsivity. We identified distinct profiles which captured varying levels of AC co-use and single use. Particular impulsivity facets identified who are at risk of membership into particularly risky (i.e., heavy use) profiles. These profiles were then linked to negative consequences to explore the consequences of problematic alcohol and cannabis use. Altogether, our findings indicate heavy co-use is predicted by certain impulsivity facets and is linked to elevated cannabis-related and alcohol-related negative consequences. Risk models and risk levels specific to negative consequences were found to be generalizable across genders. Through this study, we sought to advance the AC co-use research field by testing proposed risk models (Stamates et al., 2022), exploring the breadth of AC co-use profiles in our emerging adult sample, and linking metrics of riskiness to these profiles to identify which AC co-use profiles are the most concerning.

AC Co-use Profiles Across Gender

To explore our first aim (i.e., investigate whether the AC co-use and single use patterns differed as a function of gender), we examined the similarity of profiles across genders. First, we found the same number of latent profiles can be identified in all groups optimally. We also found that Profiles 1 and 2 were similar in structure, but not Profiles 3 and 4. These differences can mean one of two things: (1) may indicate problems with the operationalization of constructs or (2) may reflect differences in the nature of the profiles themselves in relation to the grouping variable of gender (Morin et al., 2016). Given extensive evidence suggesting certain genders (i.e., men and women) use substances differently (e.g., McHugh et al., 2018), the latter explanation may have more merit. Moreover, emerging evidence, though conflicting at this stage, also suggests AC co-use might operate similarly across genders (e.g., Lipperman-Kreda et al., 2018; Patrick et al., 2019). We also found that the profiles are not homogenous across genders. In other words, there is greater variability in basal and ceiling levels in some genders versus others. This is not surprising, as we found AC co-use profiles seemed to deviate across genders at higher levels. Lastly, we found the relative frequency in each profile is equivalent across genders. As such, this may suggest that prevalence rates across AC co-use patterns are similar.

From our final model, we identified four profiles: (1) *Heavy Alcohol Single Use and Elevated Alcohol Co-Use* Profile (2) *Primarily Moderate Alcohol Single Use* Profile (3) *Heavy Cannabis Single Use and Elevated Alcohol Co-Use // Primarily Heavy Alcohol Co-Users*, and (4) *Light AC Single Use and Elevated Alcohol Co-Use* Profile. The first two profiles were identical across all genders. Profile 1 (*Heavy Alcohol Single Use and Elevated Alcohol Co-Use*) may be indicative of individuals who increase their alcohol use on co-use days and is consistent with studies that found even small amounts of cannabis can increase alcohol quantity on co-use days (Ito et al., 2021; Boyle et al., 2024). Recent research has suggested the gender gap in drinking behaviours (e.g., quantity, frequency) is shrinking among emerging adults (Keyes et al., 2019). For Profile 2 (*Primarily Moderate Alcohol Single Use*), individuals had a relatively low use profile across all metrics, which may indicate that at basal levels of substance use, no gender difference occur. Furthermore, this was the most common profile across all the genders, thus suggesting this may capture the normative portion of the sample.

Profile 3 (*Heavy Cannabis Single Use and Elevated Alcohol Co-Use // Primarily Heavy Alcohol Co-Users*) was the most divergent profile across genders. As such, these results suggest gender may differentiate how problematic AC co-use patterns express themselves. In other words, how individuals use AC co-use severely is different across genders, which is consistent with findings by Subbaraman & Kerr (2015). Our final profile, Profile 4 (*Light AC Single Use and Elevated Alcohol Co-Use*), was identical for the women and gender-diverse groups. This pattern was different for men, except for alcohol only use (which was identical to the other gender groups). Our results are consistent with findings by Watson et al. (2020) that suggest gender-diverse individuals may AC co-use similarly to a particular subset of cis-gender women, queer women. This was only specific to gender-diverse individuals who were female at birth. In our sample, more than half of the participants who identify as gender-diverse were assigned female sex at birth.

When considering Profiles 3 and 4, gender-diverse individuals share profiles only with men (Profile 3) and only with women (Profile 4). Interestingly, in both cases, this corresponds to a more problematic use profile. Notably, the gender-diverse profile seemed to have the most overall elevated scores upon visual inspection. From a theoretical viewpoint, this is consistent with both the minority stress model (Meyer, 2003) and the self-medication hypothesis

(Khantzian, 1997), which would anticipate that gender-diverse individuals would be at heightened risk of more excessive AC co-use when compared to their cis-gender peers. Furthermore, our findings corroborate two other studies exploring alcohol and cannabis use in gender-diverse individuals (Watson et al., 2020; Dyar et al., 2024). Consistent with conclusions by Subbaraman & Kerr (2015) that posit AC co-use is a heterogenous category that likely has at least two different use patterns, we found three profiles that detail AC co-use (i.e., Profile 1, 3, and 4). Together, these person-centred analyses suggest further replication to understand the breadth of AC co-use samples in other samples pertinent to gender identity among emerging adults.

Impulsivity as a Predictor

Our second aim was to link impulsivity to these patterns as key predictors. Consistent with our first hypothesis, we found that NU, PU, and SS were all significant predictors for patterns with elevated AC co-use across all genders. Specifically, Profiles 1 and 2 were differentiated by only SS and Profiles 1 and 3 were differentiated by NU only. SS, NU, and PU differentiated between Profiles 2 and 3, and Profiles 3 and 4. However, some profile were not differentiated by any of the predictors (i.e., Profiles 1 and 4, Profiles 2 and 4). Scant research has examined impulsivity and co-use beyond dichotomies like co-use status, as this is the first study to examine different use patterns within AC co-use profiles. As such, our findings suggest that impulsivity facets may not be able to detangle particular types of co-use profiles from each other. However, the facets did identify the most problematic pattern, Profile 3 (i.e., had extreme scores on all indicators when compared to other profiles), which was the only profile that had predictors that were significantly different from all other profiles. This points to the facets of SS, NU, and PU as important personality risk factors that are linked to a pattern with elevated AC co-use and cannabis only use. Altogether, our results implicate these as key indicators of individuals who are at heightened risk of elevated and problematic AC co-use. As such, clinicians should be especially cognizant of such facets when screening for AC co-use in emerging adults.

Specific to our hypotheses regarding which predictor was the strongest, our prediction that SS would be the strongest was only partially supported, as it was only the strongest predictor for specific comparisons. Though SS was not the most consistent, it was still the strongest significant predictor for the comparison of the lightest use profile, Profile 2, and the heaviest profile, Profile 3. As such, SS may be the strongest indicator that differentiates between individuals who do not or very minimally AC co-use (e.g., Profile 2) to the most from those who are at high risk of problematic AC co-use (e.g., Profile 3). This finding is consistent with the majority of impulsivity-focused AC co-use research which implicates SS as a key predictor of AC co-use status (e.g., Stamates et al., 2022; Waddell et al., 2022). Contrary to our hypotheses, NU was the most consistently strongest predictor of problematic AC co-use patterns. For our most problematic and elevated AC co-use pattern, Profile 3, NU was the only significant indicator for all comparisons between Profile 3 and the other profiles. It was also the facet that best differentiated between Profile 3 and the next elevated AC co-use profile, Profile 4. NU also increased membership into Profile 3 when compared to the other remaining AC co-use pattern, Profile 1. Thus, it may identify those who are at risk of developing problematic AC co-use above and beyond other patterns of AC co-use. This is consistent with findings by Daros et al. (2022) that found NU was the strongest predictor. Thus, negatively emotionally valenced impulsivity may be the most reliable measure of AC co-use – as well as the strongest overall.

Although PU was not the strongest predictor, it was still a significant predictor in comparisons between (A) Profile 2 versus 3 and (B) Profile 3 versus 4. More specifically, higher

PU was linked to increased odds of membership into Profile 2 (versus 3) and Profile 4 (versus 3). This is consistent with both our hypothesis and studies that have demonstrated PU is linked to increased AC co-use (Stamates et al., 2022), though never to the same degree as NU and SS; the latter two have been implicated as the strongest predictors of the facets respectively (e.g., Daros et al., 2022; Linden-Carmichael et al., 2019). Surprisingly, we did not anticipate the directionality of PU. That is, PU may serve as a trait that significantly protects an individual from using AC co-use heavily. This may have to do with the differences between PU and NU – as PU is characterized by positive emotions and motivations, such as having fun, which may be a more adaptive motivation in contrast to NU which involves diminishing negative emotions impulsively such as using substance to numb such feelings (Daros et al., 2022; Wardell et al., 2022). Given this surprising finding, more work is needed to detangle how these impulsivity facets may increase or decrease the odds of problematic AC co-use.

Negative Consequences as an Outcome

Finally, we investigated our third objective (i.e., examine whether AC co-use profiles can predict more negative consequences). Our second hypothesis was well-supported, as the profile with the heaviest AC co-use (i.e., Profile 3) was linked to the most negative consequences. However, we did not anticipate a second profile would be on par with Profile 3 – Profile 4. Profile 3 and 4 did not significantly differ, thus suggesting both patterns are linked to similar levels of negative consequences. More specifically, both profiles were amongst the highest in both alcohol-related and cannabis-related negative consequences when compared to the other profiles. As such future studies should seek to replicate studies measuring metrics of AC co-use to extend understanding of the risk AC co-use patterns may pose.

With regards to alcohol-related negative consequences, Profile 1 did not significantly differ from Profiles 3 and 4. Taken together, this suggests all three are particularly high risk specific to alcohol use. Though no hypotheses were made regarding an elevated alcohol co-use pattern, we are not surprised by this result. Heavy drinking in itself is a problematic pattern of substance use. When coupled with co-use, such problematic use patterns are exacerbated (Boyle et al., 2024). Of note, although we did not find impulsivity facets that differentiated Profiles 1 and 4, and Profiles 2 and 4, these three profiles are different in terms of outcomes. We take this result as evidence for examining AC co-use status beyond dichotomies. Although all three types of patterns in these profiles would have been collapsed under a dichotomous measure of co-use as "co-users", they have different levels of types of risk levels (i.e., only two of the three AC co-use patterns had similar and high levels of cannabis-related and alcohol-related negative consequences). Such complexity is not captured in the dichotomous co-use status measure used in many previous studies, and thus we caution further studies from relying on only dichotomous measures of AC co-use.

Strengths, Limitations, and Future Directions

This study has a range of strengths such as examining AC co-use within a legalized cannabis context, relying on daily-level measurement based on a comprehensive recommended operationalization of AC co-use (see Lee et al., 2022 review), inclusion of both cannabis and alcohol metrics, and going beyond dichotomous measures of AC co-use. Still, this study has limitations. First, this study is cross-sectional. Therefore, our results cannot support causal, or even directional statements. Longitudinal and experimental research will thus be needed to more thoroughly investigate the directionality of the associations identified in this study. Longitudinal research will also make it possible to assess the stability of these profiles and to differentiate emerging adults who mature out of problematic use patterns from those who do not (Waddell et al., 2022). Second, some profiles were relatively small. More specifically, most of the sample (92%) corresponded to the non-problematic substance use profile (i.e., Profile 2). Although this is consistent with our inclusion criteria that did not require a minimum amount of substance use, it also meant that the low prevalence of heavy alcohol and cannabis use and co-use might have limited our ability to identify more diversified profiles. Yet, the fact that most of these profiles could be replicated across three gender groups and displayed diversified associations with predictors and outcomes supports the idea that these profiles are meaningful. Importantly, research indicates that co-use is not frequent (Jackson et al., 2020), suggesting that our results in terms of prevalence are not unexpected and that perhaps the consideration of a longer time frame might be necessary to increase variability.

Third, women made up most of the sample (64%), whereas gender-diverse individuals only represented 9% of the sample. Although the latter percentage may be representative of the actual proportion of gender-diverse individuals in the general population, increasing the number of gender-diverse participants or running a replication study specifically targeting this population may provide more insight into the unique reality of gender-diverse individuals. Fourth, this study relied entirely on self-report measures, which are recall difficulties (in retrospective measures like the TLFB) and a variety of other biases (e.g., social desirability). However, the measures used in our study are all psychometrically sound and recommended for the assessment of these constructs (e.g., Simons et al., 2015), which somehow alleviates this concern. For example, the TLFB, the main measure of substance use indices for the LPA, is correlated with biological measures of substance use (Hjorthøj et al., 2012). Yet, it could be informative to replicate the present results via the incorporation of biological markers and informant reports.

Fifth, there are currently no standardized self-report measures to assess cannabis use (i.e., dosage) in a way that is as accurate as those used for alcohol (Lee et al., 2022), which suggests that our rough measurement of cannabis use in terms of grams might have lacked precision. Indeed, even though we utilized visual aids to help aid participants, including conversions of grams and ounces, along with estimates for the number of "puffs" of a blunt and "hits" of a bong, we did not consider more specific accurate of dosage (e.g., % THC) or other modes of consumption (e.g., edibles), which should be incorporated in future studies. Sixth, even though we followed current recommendations (Lee et al., 2022) to operationalize AC use and co-use within a relatively short (i.e., daily) timeframe, we still did not consider whether co-use was simultaneous (whether effects overlap) or occurred concurrently (with no overlapping effects). It would thus seem important, for future studies, to go beyond the current study to more properly tease apart individuals who might simply be using both substances within the same given day from those who simultaneously used both substances to experience joint effects. Moreover, considering the joint use of additional legal (e.g., medications) or illegal (e.g., psychedelics, opioids, stimulants) substances might help to better understand co-use patterns among people using multiple substances.

Conclusion

Our study sought to add to the growing body of AC co-use research by exploring AC co-use profiles. We wanted to extend upon previous studies by identifying the various profiles of alcohol and cannabis users and co-users, testing out a risk model of impulsivity for AC co-users and measuring the level of risk posed by co-use via a consideration of consequences measured via established measures of negative consequences associated with the problematic use of alcohol and cannabis (i.e., the AUDIT and the CUDIT-R). To the best of our knowledge, this study is the first to assess alcohol-related and cannabis-related negative consequences of AC co-use from a person-centered (i.e., profiles) perspective. Perhaps more importantly, it is also the first study to analyse how gender identity, operationalized while specifically accounting for gender diverse individuals, influenced the nature of those profiles, the impact of impulsivity on profile membership, and the consequences of those profiles. By providing strong evidence of replication for most of our results (i.e., number of profiles, nature of three out of four profiles, size of the profiles, roles of impulsivity and consequences) across gender categories, our results support the robustness and relevance of our conclusions, showing that they do seem to extend to cis-gender men, cis-gender women, and gender-diverse individuals. By revealing some differences linked to the nature of some of the profiles, they also reveal that a profile characterized by the heavy use of cannabis, on its own or in the context of AC co-use, coupled with the heavy use of alcohol during co-use days (i.e., *Heavy Cannabis Single Use and Elevated Alcohol Co-Use)* was limited to men and gender-diverse individuals, whereas women with a similar profile co-use days are primarily marked by heavy levels of alcohol consumption (i.e., *Primarily Heavy Alcohol Co-Users*). Interestingly, gender-diverse individuals with a similar profile also tended to use more alcohol on co-use days relative to men. Although our last profile (i.e., *Light AC Single Use and Elevated Alcohol Co-Use*) also showed some differences (i.e., showing that women and gender-diverse individuals tended to use and co-use more cannabis than men).

Taken together, our results provide evidence for several important conclusions for AC co-use research: (1) co-use is a heterogenous phenomenon that needs to be examined beyond dichotomies while accounting for inter-individual heterogeneity (i.e., accounting for profiles displaying different use patterns); (2) gender differences in problematic AC co-use are limited, but still exist and should be considered in future research, whereas lighter AC patterns do not seem to differ markedly; (3) some facets of impulsivity (i.e., SS and NU) are linked to more problematic AC co-use whereas PU seems to be related to less problematic co-use profiles; and (4) integrating cannabis use measures into AC co-use research is vital to get a fuller picture about how AC co-use occurs and the risks it poses.

Our study has meaningful implications for the improved refined measurement of AC co- and AC co-use in emerging adults. These findings suggest prevention techniques should be centred around communicating the harms of combining alcohol and cannabis, which is consistent with harm reduction recommendations from Treolar et al. (2015). Specific to treatment, we suggest that considering AC co-use is crucial to identify those with the worst outcomes (i.e., those who co-use heavily) compared to those who do not (i.e., no to minimal co-use). Given the novelty of the research design, further replication and rigorous methodology may help move this research field forward. As such, we anticipate that future work should further replicate such findings to solidify and detangle how to best target problematic AC co-use in emerging adults early.

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Table 1
Descriptive Statistics for All Variables

Variable	N	Mean	SD	Cronbach's α
Use Composite Scores				
Alcohol Only Use	449	3.967	7.340	NA
Cannabis Only Use	449	.317	1.303	NA
Alcohol Co-Use	449	1.118	3.884	NA
Cannabis Co-Use	449	.158	.700	NA
Predictors				
NU	446	27.882	6.461	.829
PM	446	21.326	4.949	.846
PS	446	21.947	4.929	.810
SS	446	31.228	7.471	.865
PU	446	27.006	8.876	.945
Outcomes				
AUDIT	447	1.711	3.165	.812
CUDIT	448	2.033	3.930	.826

Note. NU = Negative Urgency; PM = (Lack of) Premeditation; PS = (Lack of) Perseverance; SS = Sensation-Seeking; PU = Positive Urgency; AUDIT = Alcohol Use Disorder Identification Test; CUDIT = Cannabis Use Disorder Identification Test; Alcohol Only Use = frequency by quantity on alcohol only days; Cannabis Only Use = frequency by quantity on cannabis only days; Alcohol Co-Use = frequency by quantity of alcohol on co-use days; Cannabis Co-Use = frequency by quantity of cannabis on co-use days; α= alpha

Table 2

Results from the Latent Profiles Analyses

Model	LL	#fp	Scaling	AIC	CAIC	BIC	ABIC	Entropy	aLMR	BLRT
Men										
1-Profile	-1036.481	8	15.399	2088.961	2119.393	2111.393	2086.099	NA	NA	NA
2-Profile	-710.658	13	5.340	1447.317	1496.769	1483.769	1442.666	1	.168	≤.001
3-Profile	-480.314	18	3.923	996.628	1065.100	1047.100	990.188	1	.336	≤.001
4-Profile	-294.837	23	5.837	635.675	723.167	700.167	627.446	1	.780	≤.001
5-Profile	-180.367	28	6.172	416.734	523.246	495.246	406.716	1	.730	≤.001
6-Profile	-97.807	33	5.630	261.615	387.147	354.147	249.808	1	.736	≤.001
7-Profile	-34.899	38	4.631	145.799	290.351	252.351	132.203	1	.359	≤.001
8-Profile	17.333	43	3.843	85.949	249.522	206.522	70.565	1	≤.001	≤.001
Women										
1-Profile	-2508.284	8	11.531	5032.567	5069.843	5061.843	5036.474	NA	NA	NA
2-Profile	-2162.799	13	9.619	4351.599	4412.172	4399.172	4347.948	1	.473	≤.001
3-Profile	-2050.449	18	10.001	4136.898	4220.769	4202.769	4145.689	.991	.916	≤.001
4-Profile	-1870.623	23	8.218	3787.247	3894.415	3871.415	3798.479	.999	.365	≤.001
5-Profile	-1770.027	28	6.322	3596.055	3726.520	3698.520	3609.729	.999	.200	≤.001
6-Profile	-1661.118	33	4.692	3388.235	3541.998	3508.998	3404.351	1	.056	≤.001
7-Profile	-1564.264	38	3.710	3204.528	3381.588	3343.588	3223.086	.999	.332	≤.001
8-Profile	-1486.476	43	3.906	3058.951	3259.309	3216.309	3079.351	1	.692	≤.001
Gender-Diverse										
1-Profile	-360.370	8	2.739	736.741	758.252	750.252	725.218	NA	NA	NA
2-Profile	-307.617	13	2.675	641.234	676.19	663.190	622.509	1	.402	≤.001
3-Profile	-278.465	18	1.656	592.929	641.329	623.329	567.002	1	.166	≤.001
4-Profile	-258.046	23	2.215	562.091	623.935	600.935	528.962	.988	.915	≤.001
5-Profile	-228.187	28	1.721	512.374	587.662	559.662	472.043	1	.381	≤.001
6-Profile	-210.730	33	1.509	487.460	576.193	543.193	439.927	1	.560	≤.001
7-Profile	-174.480	38	1.685	424.961	527.138	489.138	370.226	1	.552	≤.001
8-Profile	-148.798	43	1.527	383.596	499.218	456.218	321.659	1	.648	≤.001

Note. LL = model loglikelihood; #fp = number of free parameters; AIC = Akaïke information criterion; CAIC = consistent AIC; BIC = Bayesian information criterion; ABIC = sample-size adjusted BIC; aLMR = Lo-Mendel and Rubin's likelihood ratio test; BLRT = bootstrap likelihood ratio test; NA = not applicable.

Table 3
Fit Results from the Tests of Similarity with Covariates

Model	LL	#fp	Scaling	AIC	CAIC	BIC	ABIC	Entropy
Tests of Profile Similarity								
Configural Similarity	-2907.627	68	4.877	5951.255	6298.532	6230.532	6014.727	1.000
Structural Similarity	-3234.554	36	7.852	6541.108	6724.961	6688.961	6574.711	1.000
Partial Structural Similarity	-2944.973	43	6.282	5975.946	6195.548	6152.548	6016.082	1.000
Dispersion Similarity	-3220.209	35	6.154	6510.418	6689.164	6654.164	6543.087	1.000
Distributional Similarity	-2946.526	40	6.674	5973.051	6177.332	6137.332	6010.388	1.000
Predictors								
Effects Free – Genders	-2918.189	50	.571	5936.378	6191.618	6141.618	5982.938	.998
Predictive Similarity	-2928.562	20	.816	5897.124	5999.220	5979.220	5915.748	1.000
Outcomes								
Effects Free – Genders	-3890.123	66	4.397	7912.246	8252.186	8186.186	7976.715	.993
Explanatory Similarity	-3898.454	50	5.641	7896.908	8154.438	8104.438	7945.748	1.000

Note. LL: loglikelihood; #fp: free parameters; S.C.: scaling correction; AIC: Akaïke information criterion; CAIC: consistent AIC; BIC: Bayesian information criterion; ABIC: sample-size adjusted BIC.

Table 4

Parameter Estimates from the Final Four-Profile Solution (Distributional Similarity) By Gender

	Profile 1		Profile 2		Profile 3		Profile 4	
Men	Mean	CI	Mean	CI	Mean	CI	Mean	CI
Alcohol Only Use	7.068	[3.203; 1.31]	3.733	[3.014; 4.451]	.820	[-.062; 1.702]	.763	[-.270;1.796]
Cannabis Only Use	.545	[-.022; 1.113]	.126	[.047; .205]	18.250	[18.25; 18.25]	1.250	[.904;1.596]
Alcohol Co-Use	8.915	[7.786; 1.05]	.085	[.016; .153]	5.000	[5.00; 5.00]	7.000	[4.228;9.772]
Cannabis Co-Use	.195	[.114; .275]	.004	[.000; .007]	8.000	[8.00; 8.00]	1.500	[1.500;1.500]
	Variance	CI	Variance	CI	Variance	CI	Variance	CI
Alcohol Only Use	61.211	[23.50; 98.92]	61.211	[23.50; 98.92]	61.211	[23.50; 98.92]	61.211	[23.50; 98.92]
Cannabis Only Use	.186	[-.046; .418]	.186	[-.046; .418]	.186	[-.046; .418]	.186	[-.046; .418]
Alcohol Co-Use	.219	[.034; ..403]	.219	[.034; ..403]	.219	[.034; ..403]	.219	[.034; ..403]
Cannabis Co-Use	.000	[.000; ..001]	.000	[.000; ..001]	.000	[.000; ..001]	.000	[.000; .001]
	Profile 1		Profile 2		Profile 3		Profile 4	
Women	Mean	CI	Mean	CI	Mean	CI	Mean	CI
Alcohol Only Use	7.068	[3.203; 1.93]	3.733	[3.014; 4.451]	.820	[-.062; 1.702]	.763	[-.270; 1.796]
Cannabis Only Use	.545	[-.022; 1.113]	.126	[.047; .205]	2.062	[.251; 3.874]	3.618	[.584; 6.652]
Alcohol Co-Use	8.915	[7.786; 1.05]	.085	[.016; .153]	29.750	[24.147; 35.353]	12.527	[9.864; 15.191]
Cannabis Co-Use	.195	[.114; .275]	.004	[.000;.007]	2.688	[2.129; 3.246]	4.304	[3.328; 5.279]
	Variance	CI	Variance	CI	Variance	CI	Variance	CI
Alcohol Only Use	53.689	[6.587; 100.79]	53.689	[6.587; 100.79]	53.689	[6.587; 100.79]	53.689	[6.587; 100.79]
Cannabis Only Use	.854	[.118; 1.589]	.854	[.118; 1.589]	.854	[.118; 1.589]	.854	[.118; 1.589]
Alcohol Co-Use	1.527	[.813; 2.242]	1.527	[.813; 2.242]	1.527	[.813; 2.242]	1.527	[.813; 2.242]
Cannabis Co-Use	.054	[.021;.087]	.054	[.021;.087]	.054	[.021;.087]	.054	[.021;.087]
	Profile 1		Profile 2		Profile 3		Profile 4	
Gender-Diverse	Mean	CI	Mean	CI	Mean	CI	Mean	CI
Alcohol Only Use	7.068	[3.203; 1.934]	3.733	[3.014; 4.451]	.820	[-.062; 1.702]	.763	[-.270; 1.796]
Cannabis Only Use	.545	[-.022; 1.113]	.126	[.047; .205]	18.250	[18.25; 18.25]	3.618	[.584; 6.652]
Alcohol Co-Use	8.915	[7.786; 1.045]	.085	[.016; .153]	2.086	[2.086; 2.086]	12.527	[9.864; 15.191]
Cannabis Co-Use	.195	[.114; .275]	.004	[.000; .007]	8.000	[8.00; 8.00]	4.304	[3.328; 5.279]
	Variance	CI	Variance	CI	Variance	CI	Variance	CI
Alcohol Only Use	21.484	[5.659; 34.77]	21.484	[5.659; 34.77]	21.484	[5.659; 34.77]	21.484	[5.659; 34.77]
Cannabis Only Use	1.737	[-.643; 4.117]	1.737	[-.643; 4.117]	1.737	[-.643; 4.117]	1.737	[-.643; 4.117]
Alcohol Co-Use	5.455	[1.549; 9.362]	5.455	[1.549; 9.362]	5.455	[1.549; 9.362]	5.455	[1.549; 9.362]
Cannabis Co-Use	.259	[.012; .506]	.259	[.012; .506]	.259	[.012; .506]	.259	[.012; .506]

Note. CI: 95% Confidence Interval; Profile indicators are factor scores with mean of 0 and a standard deviation of 1; Alcohol Only Use = frequency by quantity on alcohol only days; Cannabis Only Use = frequency by quantity on cannabis only days; Alcohol Co-Use = frequency by quantity of alcohol on co-use days; Cannabis Co-Use = frequency by quantity of cannabis on co-use days; Profile 1 = *Heavy Alcohol Single Use and Elevated Alcohol Co-Use*; Profile 2= *Primarily Moderate Alcohol Single Use;* Profile 3 (men and gender-diverse) = *Heavy Cannabis Single Use and Elevated Alcohol Co-Use*; Profile 3 (women) = *Primarily Heavy Alcohol Co-Users*; Profile 4= *Light AC Single Use and Elevated Alcohol Co-Use.*

Table 5

Results from the Multinomial Logistic Regressions Predicting Profile Membership (Predictive Similarity)

	Profile 1 Vs 2		Profile 1 Vs 3		Profile 1 Vs 4	
Predictors (*M* = 0, *SD* = 1)	*Coeff* (SE)	*OR*	*Coeff* (SE)	*OR*	*Coeff* (SE)	*OR*
NU	-.089 (.440)	.915	-1.519 (.650)*	.041	.180 (.724)	1.197
PM	.326 (.360)	1.386	.362 (.458)	.442	.409 (.658)	1.505
PS	.232 (.355)	1.261	-.111 (.632)	.176	.507 (.614)	1.661
SS	.785 (.314)*	2.192	-.983 (.653)	.070	.617 (.548)	1.853
PU	-.484 (.362)	.617	.519 (.693)	.282	-1.073 (.805)	.342
	Profile 2 Vs 3		Profile 2 Vs 4		Profile 3 Vs 4	
Predictors (*M* = 0, *SD* = 1)	*Coeff* (SE)	*OR*	*Coeff* (SE)	*OR*	*Coeff* (SE)	*OR*
NU	-1.430 (.489)**	.068	.269 (.602)	1.309	1.699 (.743)*	5.468
PM	.036 (.280)	.505	.083 (.567)	1.086	.047 (.599)	1.048
PS	-.343 (.526)	.183	.276 (.521)	1.317	.619 (.729)	1.857
SS	-1.768 (.609)**	.036	-.168 (-.459)	.845	1.600 (.753)*	4.951
PU	1.003 (.492)*	.768	-.590 (.631)	.554	-1.593 (.775)*	.203

Note. *$p < .05$, **$p < .01$; SE: standard error of the coefficient; OR: Odds Ratio; NU = Negative Urgency; PM = (Lack of) Premeditation; PS = (Lack of) Perseverance; SS = Sensation-Seeking; PU = Positive Urgency; The coefficients and OR reflects the effects of the predictors on the likelihood of membership into the first listed profile relative to the second listed profile; Impulsivity scores are factor scores; Profile 1 = *Heavy Alcohol Single Use and Elevated Alcohol Co-Use*; Profile 2= *Primarily Moderate Alcohol Single Use;* Profile 3 (men and gender-diverse) = *Heavy Cannabis Single Use and Elevated Alcohol Co-Use*; Profile 3 (women) = *Primarily Heavy Alcohol Co-Users*; Profile 4= *Light AC Single Use and Elevated Alcohol Co-Use*

Table 6

Results from Explanatory Model – Between Profile Membership and the Outcomes (Explanatory Similarity)

	Profile 1		Profile 2		Profile 3		Profile 4		Significant
Outcomes (*M* = 0; *SD* = 1)	M	CI	M	CI	M	CI	M	CI	Differences
Alcohol Negative Consequences	.781	.523; 1.039	.079	.012; .146	1.325	.581; 2.070	.983	.462; 1.503	2<1=4=3
Cannabis Negative Consequences	1.059	.753; 1.365	.061	.002; .120	1.674	.740; 2.609	1.707	1.411; 2.002	2<1<4;3=4

Note. M: Mean; CI: 95% Confidence Interval; Negative consequences are factor scores (0-1); Profile 1 = *Heavy Alcohol Single Use and Elevated Alcohol Co-Use*; Profile 2= *Primarily Moderate Alcohol Single Use;* Profile 3 (men and gender-diverse) = *Heavy Cannabis Single Use and Elevated Alcohol Co-Use*; Profile 3 (women) = *Primarily Heavy Alcohol Co-Users*; Profile 4= *Light AC Single Use and Elevated Alcohol Co-Use*

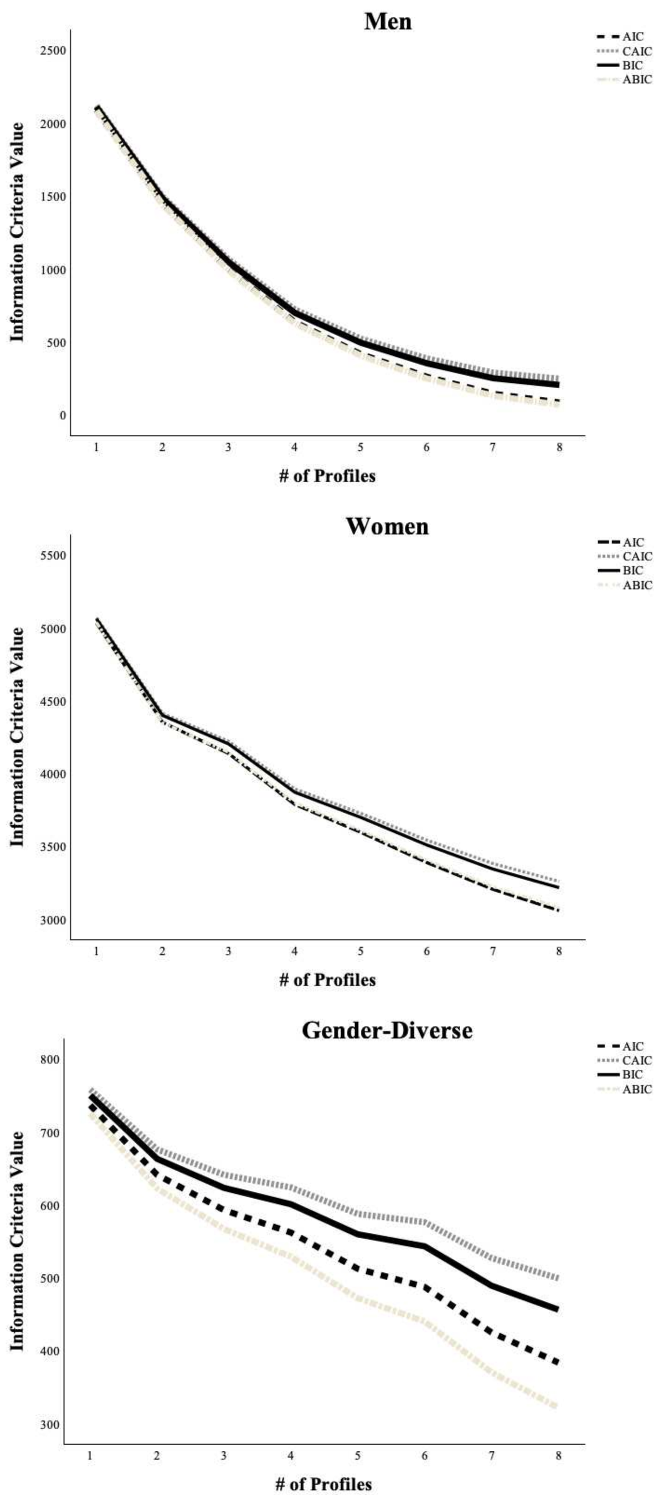


Figure 1. Elbow Plot of the Information Criteria for the Gender-Specific Latent Profile Analyses

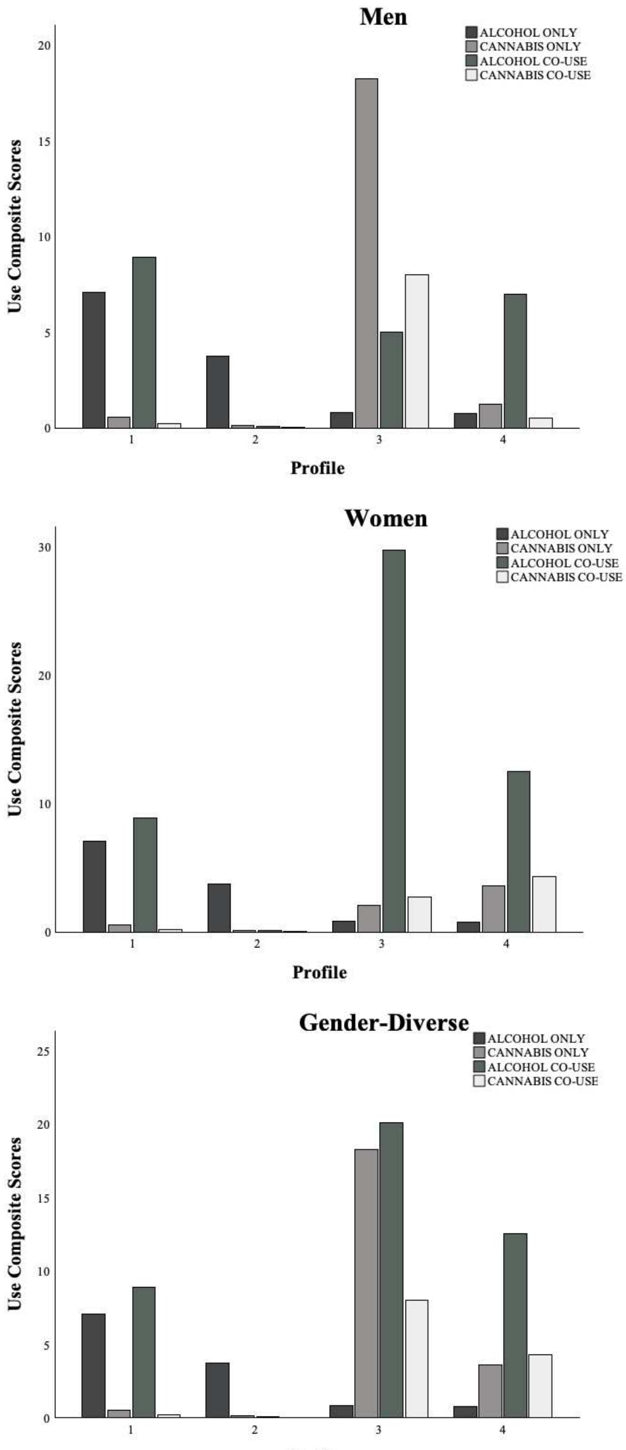
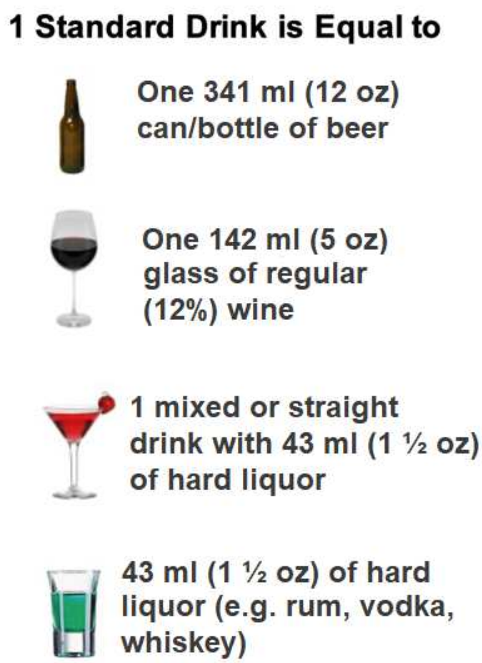


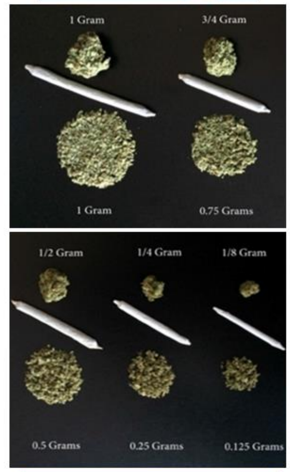
Figure 2. Final Four-Profile Solution (Distributional Similarity).

Note. Profile indicators are factor scores with grand mean of 0 and standard deviation of 1 (across referents and over time); Profile 1 = *Heavy Alcohol Single Use and Elevated Alcohol Co-Use*; Profile 2= *Primarily Moderate Alcohol Single Use;* Profile 3 (men and gender-diverse) = *Heavy Cannabis Single Use and Elevated Alcohol Co-Use*; Profile 3 (women) = *Primarily Heavy Alcohol Co-Users*; Profile 4= *Light AC Single Use and Elevated Alcohol Co-Use.*

Appendices

Appendix A: Visual Infographics Used to Aid Participants Filling out the Timeline Follow Back (TLFB)





Cannabis Quantity Chart
1 paper joint/blunt = 1/4 gram
1 skinny paper/joint = 1/8 gram
1 cone/bong hit = 1/12 gram