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Lifetime Stressor Exposure Profiles and Trait Risk for Substance Use in Young Adults

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ABSTRACT

Background: Substance use severity is shaped by a range of developmental and psychological factors, including the timing of stressor exposure across the lifespan. Previous research identified early-life stressor exposure as a factor in this progression, but emerging research has suggested the importance of considering the *timing* of stressor exposure across development. *Objectives*: Here, we tested whether distinct profiles of stressor exposure—in particular, consistent vs. mismatching patterns between early-life and recent stressor exposure—were associated with the severity of alcohol, cannabis, and nicotine use in a young adult sample of 249 college students. *Results*: A multivariate cluster analysis identified seven profiles of stressor exposure during development. Importantly, both high cumulative stressor exposure and mismatching patterns of early to recent life stressor exposure predicted greater substance use severity. Notably, follow-up ANOVA and regression analyses demonstrated the predictiveness of these stress profiles held even when including other strongly linked psychological predictors within the model. *Conclusions*: These findings suggest that both stressor patterning and individual attributes contribute to substance use severity, and advance personalized risk profiles of substance use.

KEYWORDS

Stress; stress mismatch; cumulative adversity; substance use

Substance use negatively impacts millions each year and, as a public health concern, exceeds the prevalence of many chronic diseases, including cancer and cardiovascular disease (Center for Behavioral Health Statistics, 2021). Even outside the clinical context of a diagnoseable substance use disorder, patterns of problematic substance use vary widely across individuals, especially amongst college students, who are at high-risk for (and often engage in) severe substance use behaviors (e.g., Caldeira et al., 2009; Ham & Hope, 2003; Rimsza & Moses, 2005). For college students, many of these behaviors emerge from a combination of psychological traits (e.g., differences in emotion regulation, personality, and urgency), social context, and stressor exposure (Hoffmann & Jones, 2022; Kotov et al., 2010; Smith & Cyders, 2016; Terracciano et al., 2008; Weiss et al., 2022; Welsh et al., 2019). This complexity has driven efforts to identify psychological and experiential "profiles" that explain who is more likely to develop problematic patterns of use.

Stress is a well-established risk factor for problematic substance use (al'Absi, 2018; Moustafa et al., 2021; Schwabe et al., 2011; Sinha, 2001, 2008). Lifetime exposure to stressors, particularly when chronic and/or severe, has been associated with increased problematic substance use (McHugh et al., 2020; Sinha, 2008). Lifetime exposure to stressors, particularly when chronic or severe, has been associated with increased problematic substance use and relapse vulnerability, through mechanisms such as increased cravings as a form of maladaptive coping and deficits in inhibitory control (McHugh et al., 2020; Ruisoto & Contador, 2019; Sinha, 2008, 2024). In non-clinical samples, these same mechanisms are thought to contribute to problematic substance use, or patterns of use that lead to measurable impairments or negative consequences, even in the absence of a formal substance use disorder diagnosis (Edwards et al., 2006).

A complicating factor in this line of research involves the fact that stressor exposure is not a simple, unitary construct. Indeed, unlike traditional models of stress and health, such as the allostatic load model, which posits that the cumulative impact of stress across the lifespan is most culpable for deleterious health outcomes (McEwen, 1998), emerging research suggests that it is not just the amount of stressor exposure a person has but also the timing of stressor exposure that matters (Epel et al., 2018; Shields & Slavich, 2017). According to the mismatch hypothesis of stress, individuals whose early-life stress exposure differs significantly from their recent experiences (i.e., high early stress followed by low adult stress, or the reverse) may be at relatively greater risk for negative health outcomes, including substance abuse, as compared to those without a mismatch (Nederhof & Schmidt, 2012). This elevated risk is thought to arise because their physiological and psychological systems become calibrated to one type of environment (e.g., high threat), making it harder to adapt when the adult environment no longer matches those early expectations—resulting in chronic

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dysregulation of stress response systems and increased vulnerability to maladaptive coping behaviors.

Consistent with this formulation, there is growing evidence that stressor mismatches may uniquely disrupt regulatory processes that are related to substance-related problems (though see Shields & Hunter, 2024). For example, McMullin et al. (2021) found that food addiction was predicted by both early and recent stressor exposure, whereas alcohol addiction was only associated with recent stressors. Early stages of development are particularly sensitive to stress, as this is when individuals first learn how to regulate affect and cope with adversity (Nelson & Gabard-Durnam, 2020). When early stress exposure is high, the stress response system may become calibrated to expect ongoing threat, a form of adaptive plasticity that can buffer future stress (Del Giudice et al., 2011; Ellis et al., 2017; McLaughlin & Sheridan, 2016; Slavich, 2020, 2022).

Despite this research, few studies have empirically examined developmental stressor exposure patterns (such as a mismatch between early and recent stress) to test their relations with problematic substance use. To address this gap, we aimed to identify distinct lifetime stressor exposure profiles based on early-life and recent stressors, and to test whether these profiles predicted problematic use of alcohol, cannabis, and nicotine use. Problematic use has been operationalized in this study as substance use severity, which is meant to capture the negative consequences associated with use.

To determine if these stressor exposure profiles provide unique predictive ability for substance use severity, we also examined individual differences in psychological attributes that have been previously found to predict problematic substance use, including distress intolerance, emotion regulation, risky decision-making, personality, and urgency (Hulvershorn et al., 2015; Kaiser et al., 2012; Kotov et al., 2010; Smith & Cyders, 2016; Terracciano et al., 2008; Weiss et al., 2022). Based on the research summarized above, we hypothesized that any stressor mismatch clusters would be associated with greater substance use severity, and that both stressor history and psychological attributes would explain unique variance in problematic use, suggesting that stressor exposure may contribute to substance use risk through means not fully captured by individual differences alone.

Method

Participants

Undergraduate participants ($n = 266$) were recruited from a subject pool at a mid-southern state university and received course credit for participation. An *a priori* power analysis was conducted to determine the target sample size. Detecting a small-moderate effect size $f^2 = 0.085$ (i.e., halfway between f^2 magnitudes considered small [0.02] and moderate [0.15] by convention) in 12 a model with 21 predictors (i.e., the sum of the predictors we included) with 80% power required a sample size of 268 participants. There were two attention checks spread throughout the survey. Out of the 266 participants, 17 failed both attention checks, leaving 249 with usable data. The sample was predominately female ($n = 168$; 67%), heterosexual ($n = 219$, 87%), and White ($n = 191$, 76%). Demographics can be found in Table 1. All study procedures were pre-approved by the Institutional Review Board, and all participants provided informed consent prior to study commencement.

Measures

All predictors used in the analyses are described below; for a list of all predictors in the experiment, see the Supplemental Material.

Predictors

Lifetime stressor exposure. Participants' lifetime history of stressor exposure was assessed using the Stress and Adversity Inventory for Adults (Adult STRAIN) (Slavich & Shields, 2018). The STRAIN is a NIMH/RDoC recommended

Table 1. Demographics by stressor-exposure multivariate cluster.

	Full sample $n = 249$	Cluster 1 $n = 49$	Cluster 2 $n = 37$	Cluster 3 $n = 56$	Cluster 4 $n = 22$	Cluster 5 $n = 39$	Cluster 6 $n = 29$	Cluster 7 $n = 17$
Age	19.22	18.95	19.24	19.05	19.22	19.05	20.44	18.82
Gender								
Female	68.3%	59.1%	78.3%	66.1%	72.7%	66.7%	75.8%	64.7%
Male	31.7%	40.9%	21.7%	33.9%	27.35	33.3%	24.2%	35.3%
Sexual Orientation								
Heterosexual	87.9%	97.9%	86.5%	98.2%	86.3%	82.1%	58.6%	94.1%
Homosexual	8.1%	2.1%	10.8%	0	9.1%	10.2%	31.0%	0
Other	4%	0%	2.7%	1.8%	4.6%	7.7%	10.4%	5.9%
Stressor Exposure								
Early adversity	6.16 (5.84)	6.38 (1.46)	3.78 (2.37)	2.16 (1.26)	1.81 (1.05)	12.20 (3.37)	15.03 (8.09)	0.47 (0.51)
Early adversity (standardized)		0.03 (0.25)	−0.41 (0.40)	−0.68 (0.21)	−0.74 (0.18)	1.03 (0.57)	1.52 (1.38)	−0.97 (0.08)
Recent stress	3.09 (3.01)	1.20 (0.81)	5.86 (1.05)	0.98 (0.70)	3.36 (0.49)	3.05 (1.62)	8.48 (3.47)	0 (0)
Recent stress (standardized)		−0.62 (0.27)	0.92 (0.35)	−0.69 (0.23)	0.08 (0.16)	−0.01 (0.53)	1.78 (1.15)	−1.02 (0.00)
Age of First Substance Use								
Alcohol	16.01 (2.31)	16.27 (1.84)	15.63 (1.79)	16.83 (3.21)	15.80 (1.32)	15.45 (2.39)	14.76 (1.86)	17.35 (1.59)
Cannabis	16.44 (2.47)	16.68 (1.74)	16.71 (1.61)	16.37 (4.55)	16.55 (1.42)	16.05 (1.39)	16.31 (2.82)	16.67 (1.52)
Nicotine	16.03 (2.06)	16.35 (1.81)	15.95 (1.52)	17.26 (1.66)	15.91 (1.83)	15.78 (1.62)	15.20 (3.52)	15.20 (1.30)

Note: Recent stress refers to stressors experienced over the preceding year. Values are expressed as *M* (*SD*) unless otherwise indicated.

instrument that assesses exposure to 55 potential major acute (e.g., loss of a job, death of a relative) and chronic stressors (e.g., financial difficulties, chronic illness) that have been associated with negative psychiatric and physical outcomes. Every endorsed stressor is then measured for how severe the individual rated it as, how frequently it occurred, when it occurred, and for how long it lasted. Additionally, stressors across 12 domains (e.g., housing, education, work, health, relationships) are measured. The STRAIN has excellent test-retest reliability, demonstrated strong concurrent and discriminant validity, and predictive and incremental validity across a variety of psychological, cognitive, biological, and clinical outcomes (Cazassa et al., 2019; Kim et al., 2024; Lam et al., 2019; McMullin et al., 2021; Olvera Alvarez et al., 2019; Slavich & Shields, 2018).

For the purposes of this study, all stressor types (acute vs. chronic, domains, and duration) were summed to create a cumulative stressor exposure. This approach captures the total frequency of stressor exposure, rather than weighting stressors by perceived severity, to provide an objective index of cumulative stress load consistent with prior STRAIN research (e.g., Nagpal et al., 2024; Shields et al., 2023). To ascertain early life stressor exposure for the mismatch hypothesis, all stressors that occurred from 0 to 13 years of age were summed to create an early life stressor composite, whereas recent life stress was quantified by summing all stressors that occurred over the course of the past year. Because early stressors (range: 0–35) spanned a substantially longer exposure window than recent stressors (range: 0–18), both variables were z-score standardized to place them on a comparable scale to account for the differences in range and time. Stressor match or mismatch was data-driven and assessed by clusters emerging from a multivariate cluster analysis of only early and recent life stressor exposures (see Data Analysis).

Emotion regulation. Emotion regulation was measured using the Emotion Regulation Questionnaire (ERQ) (Gross & John, 2003). The ERQ consists of 10 items and has two subscales: cognitive reappraisal and expressive suppression. Example items from the two scales include "I control my emotions by changing the way I think about the situation I'm in" and "I control my emotions by 15 not expressing them," respectively. Participants indicate how much they agreed with each statement on a 7-point Likert scale. The cognitive reappraisal scale had good internal consistency (α = 0.85), and the expressive suppression scale's internal consistency was minimally adequate (α = 0.70)

Personality. The Big-Five model of personality (conscientiousness, agreeableness, openness to experience, emotional stability, and extraversion) was assessed *via* the Big Five Inventory-II (BFI-II; Soto & John, 2017). Participants were presented with 60 statements and indicated how much they agreed with each statement using a Likert scale from 1 (*Disagree strongly*) to 5 (*Agree strongly*). Example items include "I am someone who is outgoing, sociable" (extraversion), "I am someone who values art and beauty" (openness to experience), and "I am someone who can be somewhat careless" (conscientiousness). Items are summed, with higher scores indicating more of the trait in question. Internal consistency varied but was generally good for each trait: extraversion (α = 0.85), agreeableness (α = 0.80), conscientiousness (α = 0.85), neuroticism (α = 0.87), and openness to experience (α = 0.83).

Urgency. Urgency and impulsivity were assessed with the Urgency, Premeditation, Perseverance, and Sensation Seeking Impulsive Behavior Scale (UPPS) (Cyders et al., 2007). The scale consists of five subscales Positive Urgency, Negative Urgency, Lack of Premeditation, Lack of Perseverance, and Sensation Seeking. Positive and negative urgency refer to the tendency to act impulsively due to positive and negative affect, respectively. Lack of premeditation refers to the tendency to act without prior planning (e.g., "I am not one of those people who blurt out things without thinking"). Lack of perseverance refers to a tendency to not complete tasks or goals (e.g., "I tend to give up easily"). Sensation seeking refers to motivation to for novel experiences (e.g., "I would enjoy parachute jumping"). Participants answered how much they agreed with the item on a 4-point Likert scale. Subscales were calculated by taking the sum of the relevant items. Internal consistency ranged from acceptable to good (negative urgency: α = 0.81; lack of premeditation: α = 0.80; sensation seeking: α = 0.78; lack of perseverance: α = 0.78), with only positive urgency (α = 0.66) questionable.

Outcomes

Substance uses and severities. Substance uses and their severities were measured using a modified version of the Drug Abuse Screening Test (DAST-10) (Skinner, 1982). Participants answered questions about the severity of their use for alcohol, cannabis, nicotine, and overall substance use. Because the DAST-10 functions as a screening measure of problematic use rather than diagnostic status, higher scores reflect greater substance-related problems and consequences. Participants were not screened for any substance use disorders prior to study participation, nor did they provide any diagnoses. Severity of use behaviors were recorded for both the past year and lifetime use prior to the previous year and summed into one lifetime score. These items included "Does your spouse (or parents) ever complain about your involvement with drugs?" and "Are you always able to stop using drugs when you want to?" Internal consistency was very good for both alcohol (α = 0.87) and cannabis severity of use (α = 0.85), whereas it was moderately good for nicotine (α = 0.70).

Procedure

All participants completed the study online. Participants provided informed consent before starting and filling out all measures of interest on LimeSurvey. Measures were presented in a fixed order, with the ERQ first, followed by the UPPS, BFI, STRAIN, and substance use questionnaire. Other measures not analyzed here were included throughout the survey.

Data analysis

To test our main hypothesis that stressor mismatch clusters would predict more severe substance use, we conducted a multivariate cluster analysis using the "mclust" package (v. 4.3.2) in R (v. 6.1). The mclust package uses a combination of Gaussian mixture models and the Expectation-Maximization algorithm to formulate clusters (Scrucca et al., 2016). Although stress data is typically skewed in its distribution (e.g., positive skews), the data were not transformed (e.g., neither log nor square-root transformed) other than *z*-scoring for this project in order to preserve the original scale for ease of interpretation (Burani et al., 2023). Both early and recent stressor exposure were entered into the Mclust function and made to fit into a data structure with a maximum of nine clusters (which is the default setting for the function), with no other variables included. Seven distinct clusters emerged, with attempts to fit into less clusters (e.g., four) yielding less favorable fit indices.

As there was a large discrepancy in the amount of time over which stressors could be included in our measures of early stressor exposure (13 years) and recent stressor exposure (past 1 year), these variables were standardized using the scale() function in R. To correctly handle the categorical cluster variables, all seven clusters were sum contrast-coded. This coding scheme was applied to ensure that the effects of each cluster were assessed relative to the overall mean of early and recent stressors, thus allowing for a more nuanced interpretation of how each cluster contributed to variations in the outcome.

Severity of use was then regressed onto the clusters to determine which model of stress was more predictive. The use severity outcome variable was constructed through a composite score of all items on the modified DAST-10 over an individual's lifetime. As the sample was of college-aged students, we expected the only substances to be heavily represented in the sample to be alcohol, cannabis, and nicotine. Because of this, those three substances received their own severity of use measure. Models were also fit with overall DAST-10 scores as an outcome. Next, all predictors of interest (including covariates such as age, sex, race, as well as positive/negative affect as measured by the PANAS and social desirability as measured by the SDS-17; Stöber, 2001; Watson et al., 1988) were included into Type III sum of squares ANOVA and removed *via* a reverse stepwise linear regression until only predictors that reached statistical significance were included.

Finally, as substance use scores are often right skewed (due to the number of participants who report no substance use), we re-estimated all models to assess for the robustness of our analyses by fitting the data to a Poisson distribution. These alternative specifications yielded the same pattern of results in terms of direction and statistical significance. Full results from these analyses are reported in the Supplementary Materials.

Results

Substance use

Out of the 249 participants, 232 endorsed having tried any substance that we assessed. The most-used substance was alcohol, with 208 participants (83%) having tried it over the course of their lifetime and an average severity of use score of 9.63 (range: 0–47). Nicotine was the second-most-used substance, with 107 participants (42%) having used it and an average severity of use score of 7.11 (range: 0–23); 95 participants (38%) had tried cannabis, with an average severity of use score of 2.03 (range: 0–24). A full description of participant substance use can be found in the Supplemental Material (including substances not analyzed here due to low use rates). To test for cross-use of the three main substances of interest, chi-square tests were conducted. Cannabis and nicotine had the highest co-usage, $X^2(1, N=249) = 29.69$, $p < .001$. This was followed by alcohol and cannabis, $X^2(1, N=249) = 10.34$, $p=0.001$, and finally alcohol and cannabis, $X^2(1, N=249) = 6.03$, $p<0.014$.

Lifetime stressor exposure

Participants experienced an average of 14 stressors over their lifetimes ($M=14.7$, $SD=13.07$, range: 0–111), with an average of 6 early life stressors ($M=6.16$, $SD=3.02$, range: 0–35) and 3 recent stressors ($M=3.09$, $SD=3.02$, range: 0–18); this is similar to other comparable samples (e.g., see Cazassa et al., 2019; Slavich et al., 2019; Slavich & Shields, 2018).

Stressor clusters

The cluster analysis produced seven distinct groups based on the combination of early life and recent life stressors. The best-fitting model was created with unequal variance clustering, where the BIC for the model was −2680.24. The next-best model had 4 clusters with a BIC of − 2680.47. For ease of interpretation, all clusters are presented with a descriptive name, and means of stressor exposure are reported as *z* scores (see Figure 1). To determine whether the cluster represented a mismatch of early and recent stressors (relative to the sample), paired samples *t*-tests were conducted for each cluster.

The first cluster ($n=49$), referred to as the Average Early Stressor Exposure, Low Recent Stressor Exposure Cluster, had an average amount of stressor exposure during childhood (relative to the full sample) ($M_z = 0.03$), with their recent stressor exposure decreasing to just over one half of a standard deviation below the sample mean ($M_z = -0.62$). This decrease represents a mismatch in stressor exposure, with these individuals experiencing a similar amount of stress to their peers during childhood, but less over the past year, $t(48) = 11.16$, $p < .001$. The second cluster, the Low Early Stressor Exposure, High Recent Stressor Exposure Cluster ($n=37$), displayed a mismatched increase in stress. Initially experiencing lower stress levels than their peers during early life ($M_z = -0.41$), they encountered an increase in recent stressor exposure ($M_z = 0.92$), $t(36) = -12.53$, $p < .001$. The third cluster, the Consistently Low Stressor Exposure Cluster ($n=56$), maintained low stress levels at both early ($M_z = -0.68$) and recent times ($M_z = -0.69$), $t(55) = 0.31$, $p = .756$. Cluster 4, the Increasing to Average Stressor Exposure Cluster ($n=22$), had initially lower early

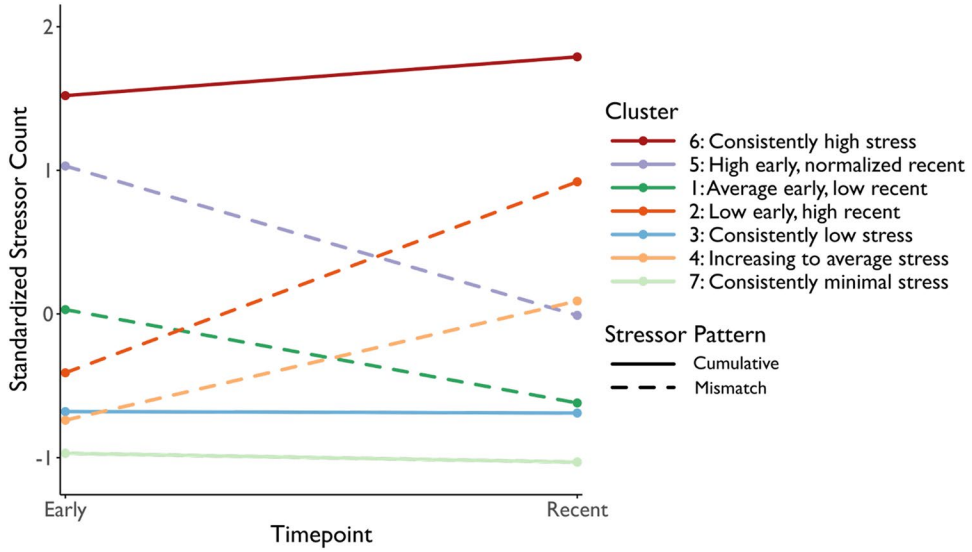

Figure 1. The stressor exposure clusters. Clusters 1, 2, 4, and 5 are examples of mismatches between early and recent stressor exposure, whereas clusters 3, 6, and 7 are examples of cumulative stressor exposure.

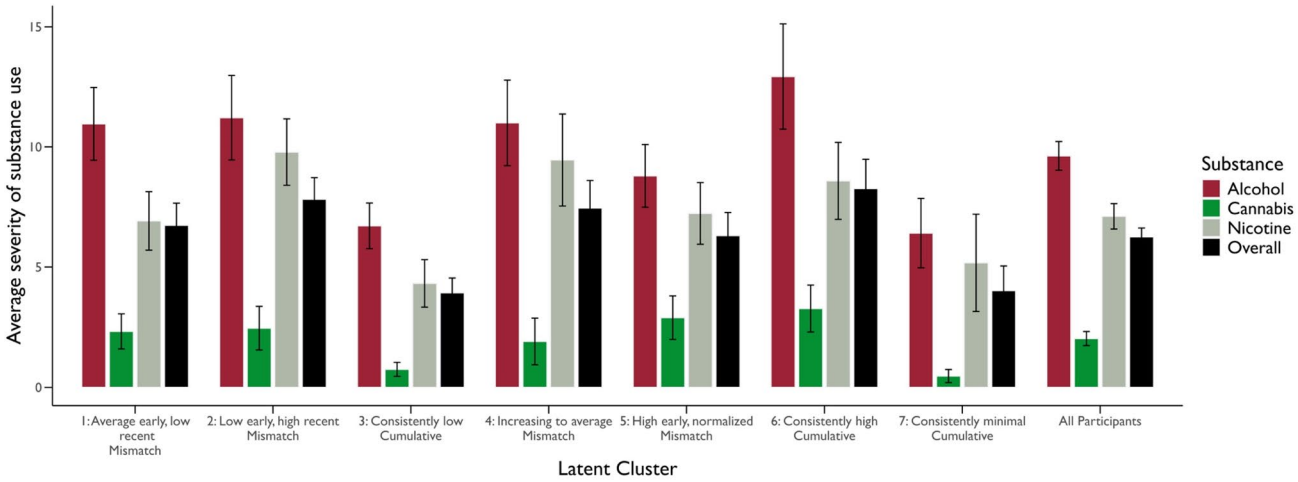

Figure 2. Estimated marginal means (EMM) of severity of substance use for all substances in the sample by cluster. For each substance, the EMM controls for every variable in its final model. Error bars represent standard error.

stressor exposure (M_z = −0.74) compared to their peers, but saw their stress levels normalize to the average (M_z = 0.09) over the past year, $t(21)$ = − 15.69, $p < .001$. The fifth cluster, the High Early, Normalized Recent Cluster (n = 39), started with considerably higher early stressor exposure (M_z = 1.03) but saw a reduction toward the sample average over the past year (M_z = −0.01), $t(38)$ = 7.21, $p < .001$. The sixth cluster, the Consistently High Stressor Exposure Cluster (n = 29), exhibited the most stress levels within the sample, with both early (M_z = 1.52) and recent stressor exposure (M_z = 1.79) being the highest among the clusters, $t(28)$ = −0.63, p = .531. This consistent high level of stress underscores the high cumulative effects associated with chronic stressor exposure. Finally, the Consistently Minimal Stressor Exposure Cluster (n = 17) reported almost no stressors in both early life (M_z = −0.97) and recently (M_z = −1.03), though they did show a very small mismatch, $t(16)$ = 2.41, p = 0.028.

Severity of use by stressor cluster

Severity of substance use was calculated for alcohol, cannabis, and nicotine by combining severity of use scores for both the past year and prior to the past year (see Figure 2). All predictors as well as multivariate clusters were used as predictors for severity scores of all three substances, in addition to scores on the DAST-10.

Throughout the entire sample, alcohol use severity scores ranged from 0 to 47, with an average severity score of 9.63 (SD = 9.41). Results of the reverse stepwise Type III SSs ANOVA can be seen in Table 2. Lack of premeditative thought (β = 0.22, p = 0.003), positive urgency (β = 0.17, p = 0.015), conscientiousness (β = 0.21, p = 0.005), sensation seeking (β = 0.13, p = 0.037), agreeableness (β = −0.17, p = 0.007), and social desirability (β = 0.13, p = 0.035) were all significant predictors of alcohol use severity. Table 3 presents the estimated marginal means of alcohol use severity for each cluster, controlling for all significant predictors; two

Table 2. Results of Type III SSs AOVA predicting severity of substance use.

Outcome	Predictors	Sum of squares	*df*	*F*	*p*
Alcohol use severity	Intercept	194.3	1	2.61	.107
	Stressor cluster[1]	1328.5	6	2.97	.008
	Social desirability	334.4	1	4.49	.035
	Agreeableness	543.6	1	7.30	.007
	Conscientiousness	595.1	1	7.99	.005
	Lack of premeditative thought	666.5	1	8.95	.003
	Positive urgency	446.0	1	5.99	.015
	Sensation seeking	326.0	1	4.73	.037
	Residuals	17567.9	236		
Cannabis use severity	Intercept	90.1	1	4.51	.034
	Stressor cluster[1]	273.2	6	2.28	.036
	Reappraisal	148.7	1	7.44	.006
	Lack of premeditative thought	165.1	1	8.26	.004
	Residuals	4793.2	240		
Nicotine use severity	Intercept	0.1	1	0.01	.971
	Stressor cluster[1]	874.5	6	2.37	.030
	Extraversion	687.1	1	11.19	<.001
	Agreeableness	313.9	1	5.11	.024
	Positive urgency	538.2	1	8.77	.003
Overall use severity	Residuals	14667.0	239		
	Intercept	3.62	1	1.33	.249
	Stressor cluster[1]	52.04	6	3.19	.004
	Social desirability	11.22	1	4.12	.043
	Lack of premeditative thought	15.46	1	5.68	.017
	Sensation seeking	16.60	1	6.10	.014
	Residuals	649.55	239		

[1]Clusters refer to the multivariate clustering. Cluster formation was generated using stressor exposure from early adversity stressors and recent (i.e., past year) stressors.

Table 3. Estimated marginal means of alcohol, cannabis, nicotine, and overall use severity within multivariate stress clusters, controlling for significant predictors in the respective ANOVAs shown in Table 2.

		95 % CI			95 % CI			95 % CI			95 % CI	
	Mean of alcohol use severity (*SE*)	*LL*	*UL*	Mean of cannabis use severity (*SE*)	*LL*	*UL*	Mean of nicotine use severity (*SE*)	*LL*	*UL*	Mean of DAST-10 (*SE*)	*LL*	*UL*
Full sample	9.62 (0.55)	–	–	2.02 (0.27)	–	–	7.11 (0.49)	–	–	1.73 (1.02)	–	–
Cluster 1 (Average early stressors, low recent stressors) - Mismatch	11.48 (1.25)	9.03	13.94	2.48 (0.64)	1.22	3.75	7.78 (1.13)	5.55	10.01	1.86 (0.23)	1.42	2.36
Cluster 2 (Low early stressors, high recent stressors) - Mismatch	9.90 (1.44)	7.07	12.74	2.46 (0.74)	1.01	3.92	9.13 (1.30)	6.57	11.69	2.02 (0.27)	1.48	2.56
Cluster 3 (Consistently low stressors) - Cumulative	6.78 (1.17)	4.47	9.09	0.52 (0.60)	−0.66	1.71	4.22 (1.05)	2.15	6.28	1.29 (0.22)	0.85	1.73
Cluster 4 (Increasing to average stressors) - Mismatch	11.28 (1.86)	7.61	14.94	2.23 (0.95)	0.34	4.12	9.57 (1.68)	6.27	12.88	1.39 (0.35)	0.69	2.09
Cluster 5 (High early stressors, normalized recent stressors) - Mismatch	9.07 (1.39)	6.34	11.80	2.91 (0.71)	1.49	4.32	7.31 (1.26)	4.38	9.79	2.06 (0.26)	1.55	2.59
Cluster 6 (Consistently high stressors) - Cumulative	13.50 (1.64)	10.28	16.72	3.31 (0.83)	1.68	4.95	8.14 (1.46	5.26	11.01	2.34 (0.31)	1.74	2.95
Cluster 7 (Consistently minimal stressors) - Cumulative	5.59 (2.12)	1.42	9.76	0.23 (1.08)	−1.91	2.38	4.89 (1.91)	1.13	8.65	0.67 (0.40)	−0.11	1.46

mismatch clusters (Average Early Stress/Low Recent Stress and Increasing to Average Stress) and one cumulative cluster (Consistently High Stress) had the highest severity of use scores, whereas the Consistently Minimal Stress Cluster had the least. Pairwise contrasts between each group are shown in the Supplemental Materials.

The sample mean of cannabis use severity was 2.03 ($SD = 4.6$; range: 0–24). Results of the reverse stepwise type 3 ANOVA can be seen in Table 2. Cognitive reappraisal ($\beta = 0.18$, $p = 0.006$) and lack of premeditative thought ($\beta = 0.19$, $p = 0.004$) were both significant positive predictors of cannabis use severity. Table 3 shows the estimated marginal means of severity scores for each cluster while controlling for all significant predictors; pairwise contrasts between the clusters are shown in the Supplemental Materials.

The sample mean of nicotine use severity was 7.11 ($SD = 8.36$; range: 0–23). Results of the reverse stepwise Type III SSs ANOVA can be seen in Table 2. Extraversion ($\beta = 0.20$, $p < 0.001$), agreeableness ($\beta = -0.14$, $p = 0.024$), and positive urgency ($\beta = 0.18$, $p = 0.003$) were all significant predictors of severity of use. Table 3 shows the estimated marginal means of severity scores for each cluster while controlling for all significant predictors; pairwise contrasts between the clusters are shown in the Supplemental Material.

Finally, the sample mean for the overall substance use was 1.73 ($SD = 1.74$; range: 0–10). Results of the reverse stepwise Type III SSs ANOVA can be seen in Table 2. Social desirability ($\beta = 0.13$, $p = 0.043$), sensation seeking ($\beta = 0.15$, $p = 0.014$), and lack of premeditative thought ($\beta = 0.15$, $p = 0.017$) were all significant predictors of overall substance use severity. Table 3 shows estimated marginal means of DAST-10 scores for each cluster while controlling for all significant predictors; pairwise contrasts between the clusters are shown in the Supplemental Materials.

Discussion

This study aimed to clarify how patterns of stressor exposure across development relate to the severity of substance use, specifically alcohol, cannabis, and nicotine. The primary hypothesis, derived from the mismatch hypothesis of stress, predicted that mismatches between early and recent stress would uniquely be associated with substance use severity. A multivariate cluster analysis produced seven distinct stress-exposure profiles, capturing both cumulative and mismatched patterns of lifetime stress. We found that for all three substances, the stress clusters that represented both mismatches (i.e., incongruent stress levels between early life and the past-year) and high accumulative effects of stress (i.e., the allostatic model) were most predictive of greater severity of substance use. Crucially, both mismatch and high cumulative stressor clusters did not outperform one another, indicating that both theoretical perspectives on stress contribute uniquely to understanding problematic substance use. Additionally, each substance had various psychological traits connected with greater severity of use.

The seven distinct stress clusters were moderately successful at predicting severity of use scores. Across all severity scores, the Average Early Stressor Exposure, Reduced Recent Stressor Exposure Cluster was most likely to display high severity of use. Out of the stress mismatch clusters, the Average Early/Reduced Recent Stressor Exposure Cluster's mismatch between early and recent stressor exposure was moderately sized. The High Early/Normalized Recent Stressor Exposure Cluster, which had the largest stress mismatch in the sample, was not more likely to have higher severity of use scores for any substances relative to any other individual cluster. Individuals in this cluster had double the average of early stress but dropped below the sample mean of recent stress. Coupled with cluster of Average Early/Reduced Recent Stressor's heightened use severity and moderate mismatch, this could be indicative that another factor to consider when looking at stressor mismatch is the size of the mismatch. Whereas the intuitive logic of the cumulative effects of stress hypothesis posits that greater stress leads to worse outcomes, this might not be translatable to the mismatch. In Schmidt (2011) original proposal of the mismatch hypothesis of stress and health, they argued that individual factors would be determine if an individual was more susceptible to the cumulative effects of allostatic load or to a mismatch between early and recent environments. These findings could offer another layer of understanding to how to interpret the implications of the mismatch hypothesis on health outcomes.

Across all the tested substance use severity variables, there was consistently at least one cluster that significantly differed from the Consistently Minimal Stressor Exposure Cluster, even when controlling for relevant variables. This could be indicative of how strong the relation between stress and severity of substance use is, with stress as the common risk factor. Clearly, exposure to stressors in any capacity (whether it is total accumulation or a mismatch) is more conducive of severe substance use than not experiencing stress. Due to their underlying biology, both chronic and mismatched stressor exposure have the capacity to disrupt many of the protective cognitive factors that could shield one from severe levels of substance use (Arnsten, 2009; Sinha, 2008).

Individual differences in psychological predictors

Crucially to the core prediction of this study, stressor exposure profiles predicted severity of substance use beyond stable individual differences in psychological attributes. The fact that stress retained predictive power, even with attributes like conscientiousness, impulsivity, and reappraisal in the model, suggests that environmental pressures may interact with or override dispositional tendencies in driving substance-related outcomes.

When examining individual predictors, several personality variables were significantly associated with use severity. Conscientiousness, agreeableness, and extraversion aligned with prior research linking personality to substance use (Kotov et al., 2010; Terracciano et al., 2008). Notably, conscientiousness positively predicted alcohol use severity. Although this might be initially counterintuitive (and contradicts previous findings regarding a negative association

between alcohol use and conscientiousness in college students, e.g., see Ham & Hope, 2003), it is possible that a sample of college students has highly conscientious people who binge drink on the weekends to alleviate stress. That is, high-conscientious students might use alcohol more to cope with the stress of college life, in a "work-hard, play-hard" mentality.

Another counterintuitive finding was the positive relationship between cognitive reappraisal and cannabis use severity. Although reappraisal is generally adaptive, its effects may be context-dependent (Troy et al., 2013). In this case, higher self-reported reappraisal may reflect a perceived ability to shift perspective facilitated by cannabis, mimicking—but not necessarily engaging—the cognitive processes of deliberate reappraisal. This interpretation aligns with prior research suggesting reappraisal's effectiveness depends on context and capacity (Webb et al., 2012). Thus, the elevated reappraisal scores in this subsample may indicate a compensatory or pharmacologically assisted mechanism, rather than a prototypical use of reappraisal as defined in traditional emotion regulation models.

Impulsivity-related traits also played a role. Lack of premeditation predicted alcohol and cannabis use, and positive urgency predicted alcohol and nicotine use. These traits may increase risk by impairing planning and promoting disinhibition during elevated mood states. Given that alcohol and nicotine are often consumed in celebratory or social settings, these environments may amplify such traits' influence.

Nicotine use, in particular, may be contextually driven. Despite reductions in smoking rates (Golechha, 2016), social vaping has increased, particularly in settings where alcohol is present (Russell et al., 2022). The disinhibitory effects of alcohol may enhance susceptibility to using nicotine products (Källmén & Gustafson, 1998). In addition to alcohol, nicotine is also often used in conjunction with cannabis, adding further complexity to understanding use profiles (Kumar et al., 2020). Sensation seeking also predicted nicotine use severity, though future longitudinal work is needed to clarify whether sensation seeking leads to use or vice versa (Crummy et al., 2020).

Strengths and limitations

This study had a number of strengths, including a robust analytical plan, strong theoretical background, and well-validated measures including of lifetime stressor exposure. Nonetheless, some limitations should be noted. First, it is likely that there are relevant predictors that were not included. For example, the nicotine model did not assess whether a participant had family members who smoked, which is a robust predictor of smoking behaviors (Avenevoli & Merikangas, 2003; Hill et al., 2005). Another potentially missed predictor was family history of substance use severity. Family history of problematic use is a strong predictor of substance use severity, stemming from both genetics and learned behavior (Coviello et al., 2004). As the models exhibited mixed predictive ability, future use should consider more specialized predictors for each substance.

Some additional limitations include the reliance on self-report data, specifically retroactive assessment of participants' stressor history, as well as the limited sample size (although it should be noted that the sample reached adequate power to reproduce previous findings). The stress clusters were created solely using stressor exposure. As the STRAIN also assesses severity, timing, and duration of stressor exposure, as well as psychosocial characteristics of stressors such as humiliation and interpersonal loss, future research should incorporate each of these variables.

The sample was also WEIRD (White, educated, industrialized, rich, and democratic) (Henrich et al., 2010). Finally, participants were young adults in college, which tends to consist less of individuals from lower socioeconomic status. These factors limit the generalizability of the findings, as many of the participants in this study likely have not been in situations where they would have tried many of the substances in this study.

Conclusion

In conclusion, we examined whether lifetime stressor history and multiple psychological traits and attributes predict severity of alcohol, cannabis, nicotine, and overall substance use in young adults. Mismatched stressor experiences and cumulative stressors independently predict higher substance use severity, suggesting distinct but potentially interacting pathways to risk. By showing the predictive ability of different stressor exposure timelines, future research should aim to clarify the mechanisms through which early and later adversity shape substance use trajectories, in both non-clinical and clinical samples. Integrating longitudinal designs and physiological indices of stress responsivity (e.g., hair cortisol, alpha amylase, etc.) could help identify the developmental inflection points at which stress adaptation becomes maladaptive. These findings highlight opportunities for personalized prevention strategies and interventions tailored to specific stress profiles and personality traits, as interventions might benefit from understanding whether the individual has experienced chronic cumulative stress or is experiencing a mismatch. Ultimately, integrating developmental stress patterns into substance-use research offers considerable promise for refining our understanding of addiction risk and informing targeted therapeutic approaches.

Author contribution

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Investigation: Z.J.G.
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