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Regular Article

Risk factors for early use of e-cigarettes and alcohol: Dimensions and profiles of temperament

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Abstract

Adolescent e-cigarette use has been labeled an epidemic and alcohol use during this developmental period is associated with deleterious outcomes. Though specific temperamental dimensions have been shown to predict substance use, profiles of temperament have rarely been examined as predictors. This study examines dimensions and profiles of adolescent temperament as predictors of early use of e-cigarettes and alcohol. The sample was comprised of adolescent (62.07% female, 87.59% White, 82.76% Hispanic/Latinx)/caregiver dyads ($N = 146$) who completed the first two timepoints (M age at second timepoint = 16.16, $SD = 0.68$) of a longitudinal adolescent substance use study. Models showed parent-reported effortful control predicted protection against adolescent use of e-cigarettes, whereas adolescent report of effortful control predicted protection against alcohol use. Though dissimilar in temperamental pattern, three profiles emerged from both parent- and adolescent-report-based latent profile analysis models. Adolescents characterized by parents as displaying a *Resilient* profile had greater odds of e-cigarette use than those characterized by a Reserved profile, whereas adolescents who self-characterized as *Mixed-type* had markedly greater odds of alcohol use than those who self-characterized as *Resilient*. Utilization of temperamental profiles may aid in identification of particularly vulnerable subgroups of adolescents who may benefit from relevant preventative programing.

Keywords: adolescent; alcohol; e-cigarette; latent profile analysis; temperament

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With the prevalence of electronic (e-)cigarette use during adolescence reaching epidemic levels (Office of the Surgeon General, 2018) and alcohol consumption among this age group showing no sign of reduction (Kann et al., 2018), these substances have become, alongside marijuana, those which are typically initiated first. This statement is made with the knowledge that early use of combustible cigarettes has shown a significant linear decline in the past decade, with e-cigarettes currently far surpassing their traditional counterparts in teen prevalence (Kann et al., 2018). The importance of e-cigarette and alcohol use among adolescents is further highlighted by the associated deleterious outcomes, with even mild to moderate early use of either substance showing potentially permanent changes in brain structure and functioning (Leal-López et al., 2020; Park et al., 2020).[1] Further, all levels of early e-cigarette use have been associated with increased prevalence of later combustible cigarette use (Park et al., 2020). Early use of alcohol has been associated with psychosocial harms (e.g., problems with family/friends, academic interference; Wicki et al., 2018) and increased mortality (Boden et al., 2019).

Given the high prevalence and serious consequences related to early use of e-cigarettes and alcohol, clinicians and scientists have sought to identify factors which may increase vulnerability for such use. For example, temperament (i.e., the biological foundation of individualized levels of reactivity and regulation upon which later emerging personality is built; Buss & Plomin, 1975; Rothbart & Derryberry, 1981) and personality (i.e., an individual's particular set of cognitions, values, and beliefs arising from the coupling of temperamental genotype and social learning; Gottesman, 1963; Rothbart, 2007) have been found to differentially predict early use (Li et al., 2017). E-cigarette and alcohol use initiation typically occurs during early- to mid-adolescence (Johnston et al., 2020). As personality has been shown to mature well into early adulthood, vulnerability for early substance use may be better conceptualized via differences in temperament, which being biologically rooted shows relative consistency across this developmental period (Mammadov et al., 2019). Still, temperament is flexible to the extent that tasks and experiences across early development may strengthen or limit an individual's biologically-based tendencies of reactivity and regulation (Kapetanovic et al., 2020). Thus, dimensions of temperament become increasingly multifaceted with age (Latham et al., 2020). It follows that, to be a reliable predictor of early e-cigarette and alcohol use, temperament may be best assessed proximal to onset of such use (i.e., early

[1]This study was originally created with the intent of examining all three of the typically early initiated substances (i.e., e-cigarettes, alcohol, marijuana). Though not entirely surprising, with consideration of the high geographic variability in the rates of adolescent marijuana use (Kann et al., 2018), marijuana use within the current sample was negligible and its examination was subsequently dropped from the study.

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adolescence). Yet, there is a notable dearth of work examining early adolescent temperament on early stages of substance use.

Though an abundance of prominent temperament theories exist, of note is Rothbart's Psychobiological Theory of Temperament (Rothbart & Derryberry, 1981). The theory was originally constructed upon the three temperamentally-based reactive and regulatory dimensions of negative affect (i.e., tendency toward irritability, sadness, and frustration in *reaction* to limitations), surgency (i.e., tendency toward *reacting* in a spontaneous and sociable manner, with a desire to seek out and enjoy intense experiences), and effortful control (i.e., capacity to *regulate* behavior through inhibition of a dominant response in favor of a more appropriate nondominant response). Ellis and Rothbart (2001) later added the fourth temperamental dimension of affiliativeness (i.e., tendency to *react* with concern for others and a desire for interpersonal closeness) to the original three. Accordingly, Ellis and Rothbart's Early Adolescent Temperament Questionnaire (EATQ-R) allows for the assessment of these four dimensions of temperament during this critical developmental period.

Of note, Rothbart (2007) has stated that "temperament theory goes beyond a list of unrelated traits or broad dimensions." Specifically, she has maintained that the interaction between an individual's reactions (e.g., negative affect, surgency, affiliativeness) and attempts to regulate such reactions (e.g., effortful control) is central to such theory. It has been further argued that sole analysis of singular dimensions of temperament fails to account for the marked correlational and bidirectional effects among these dimensions within the individual (Hirvonen et al., 2018). Moreover, it has been suggested that over-emphasis of the singular dimensions of temperament may obfuscate unique temperamental patterns (i.e., profiles), which commonly occur within subgroups of individuals (Nigg, 2006). For example, an adolescent characterized by high levels of negative affectivity may be at increased risk of developing a psychological disorder, but should they also possess high levels of effortful control such risk may be ameliorated (Hoffmann et al., 2017). Though sufficient evidence exists regarding the importance of assessing temperamental profiles, such comprehensive assessments of temperament appear with far less frequency than do studies of individual dimensions of temperament.

A key exception is the work of Hirvonen and colleagues (2018) that used the EATQ-R (Ellis & Rothbart, 2001) to examine adolescents' and mothers' temperamental profiles. This examination, solely utilizing self-report of temperament, resulted in four unique adolescent temperamental profiles: a *Resilient* profile (i.e., high effortful control, low negative affect, high surgency, moderate affiliativeness), an *Average* profile (i.e., average levels of all temperamental dimensions), a *Reserved* profile (i.e., moderate to high effortful control, low negative affect, low surgency, low to moderate affiliativeness), and a *Mixed-type* profile (i.e., labeled non-desirable in previous studies, combining the least favorable aspects of the traditional Overcontrolled and Undercontrolled types; low effortful control, high negative affect, low surgency, low affiliativeness; Hirvonen et al., 2018). As evidenced by this sole reference to existing adolescent profiles of temperament, which did not occur within a study of adolescent substance use, there remains an extreme paucity of work in which profiles of adolescent temperament are examined.

Hirvonen and colleagues (2018) employed latent profile analysis (LPA) to identify and group individuals according to patterns of temperamental dimensions. Differing from traditional analyses that examine associations between individual variables and outcomes across entire samples, LPA has the capability to identify homogeneous groups, characterized by similar patterns of the observed characteristics, within a sample (Rabinowitz et al., 2019). Since the association between temperament and clinical syndromes are likely dependent upon the unique interplay between dimensions of temperament (i.e., profiles) within an individual, LPA appears well-suited to such examinations.

A further methodological consideration which appears underutilized within the literature of adolescent temperament is multiple-informant reporting. Methodologically considered a best practice, it has been theorized that multiple informants provide unique perceptions of behaviors, emotions, thoughts, and difficulties, drawn from differing vantage points (Achenbach, 2011; De Los Reyes et al., 2013). This may be particularly true during early adolescence, as youth show a growing ability to reliably report on their own behavior and emotions (Latham et al., 2020). Nonetheless, an additional reporter (e.g., parent) continues to provide a counterpoint to the biases which often affect self-report data (Latham et al., 2020). From this, a lack of convergence between reporter ratings of adolescent temperament would appear expected and has indeed been found (Boson et al., 2018). Further, though discordance in informant ratings is often treated as error, it is possible that such discord is itself the valid, informant-specific information touted by Achenbach (2011) and De Los Reyes and colleagues (2013) in reference to multiple-informant methods. As such, retaining informant-specific results may be imperative to an accurate understanding of each individual's viewpoint (Kopala-Sibley et al., 2018). Nonetheless, it is quite possible that the concerns which often accompany discordant multi-informant ratings explain, in part, the paucity of informant-specific examinations of adolescent temperament within extant literature.

Current study

This study examined both dimensions (i.e., via path analysis) and profiles (i.e., via LPA) of temperament as potential predictors of early e-cigarette and alcohol use during adolescence, as these are the substances that are typically initiated first. Importantly, the geographic location of the present study (i.e., South Florida) provided the unique ability to examine e-cigarette use among a predominantly Latinx adolescent sample. As previous work has identified Latinx youth to be particularly vulnerable to early e-cigarette use (Kann et al., 2018), this factor further increases the utility of this study. The present study additionally employed the methodological "best practice" of multi-informant ratings (i.e., parent- and adolescent self-report) of adolescent temperament.

Prior work has found social motivations for early use of e-cigarettes (Gentina et al., 2017; Kong et al., 2021) and alcohol (Hallgren et al., 2017; Kirkpatrick et al., 2021). As such, it was hypothesized that elevated levels of surgency and affiliativeness (Ellis & Rothbart, 2001) and low levels of effortful control (Hoffmann et al., 2017) would predict both e-cigarette and alcohol use, with affiliativeness most significantly and positively associated with e-cigarette use.

As extant profiles of adolescent temperament are rare, current hypotheses regarding temperament profiles were based upon the four profiles of adolescent temperament found by Hirvonen and colleagues (2018; Resilient, Average, Reserved, Mixed-type). Though posited that a combination of profiles similar to these would emerge from within the current sample, this position was tempered by the extreme paucity of relevant temperament

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literature from which to draw additional potential parallels. As adolescents displaying a *Resilient* profile were previously found to be the most adaptive with regard to socioemotional functioning (Hirvonen et al., 2018), it was posited that membership in this profile would be protective against alcohol use among the present sample. Conversely, as Hirvonen and colleagues found the *Mixed-type* profile to be the most maladaptive, it was hypothesized that adolescents within the present sample displaying a similar profile would be the most likely to engage in alcohol use. Notably, prior work highlights the marked differences between adolescent e-cigarette use motivations (e.g., flavors, vaping tricks) and motivations toward use of other substances, including alcohol and combustible cigarettes, during this developmental period (Kong et al., 2019; Morean et al., 2018). These unique and primarily social motivations, which are currently driving the popularity of e-cigarette use among adolescents, appear to be creating a much larger and more diverse group of users than has been traditionally seen among adolescent substance users (Kann et al., 2014, 2018). Moreover, there exist no directly relevant studies from which to inform current e-cigarette profile hypotheses. As such, no specific hypotheses were made regarding profile type differentially predicting adolescent e-cigarette use within the present study.

With regard to multiple-informant (i.e., parent, adolescent) ratings of temperament, it was posited that above outlined expectations would hold across informants. Moreover, within the expected parameters, it was hypothesized that ratings would be informant specific as suggested by De Los Reyes and colleagues (2013). The expected variety in ratings was posited to provide a rich and comprehensive picture of adolescent temperament garnered from multiple viewpoints.

Method

Participants

Participants were adolescent/caregiver dyads ($N = 264$) who had completed the first assessment timepoint (T1) of an ongoing longitudinal, multiassessment study primarily investigating adolescent e-cigarette use. Adolescent participants had to: (a) be a freshman or sophomore at a South Florida area high school when first enrolled in the present study, at T1, (b) have no diagnosis of a learning or intellectual disability, (c) have no physical disability that would make it difficult to complete questionnaires, (d) have no diagnosis of a neurological disease, (e) have no diagnosis of a severe mental health problem, as well as (f) be able to speak and understand English.

Adolescent participants, during T1 ($M_{age} = 14.90$, $SD = 0.68$), were mostly female (50.76%), White (84.47%), and Hispanic/Latinx (85.61%). Though a portion of the statistical analyses within the present study utilized data solely from the 146 adolescent participants who had completed the second assessment timepoint (i.e., T2; approximately 15 months after completion of T1) of the ongoing study at the time of this study, the demographic information was largely the same for this subsample (Mage [T1] = 14.99, $SD = 0.71$; 62.07% female, 87.59% White, 82.76% Hispanic/Latinx). It should be noted that biological sex was significantly different between the two groups and will be addressed below.

Procedure

Study staff contacted local area high schools regarding their interest in allowing staff to recruit students. Of the 21 schools contacted, recruitment events were held at 11 (52.4%). During events, students completed a form requesting their contact information, as well as that of their caregiver, who were then contacted and provided with study information. Eligibility screens were completed by phone. While adolescent participants had to be proficient in English, caregivers had to be proficient in either English or Spanish, as caregiver assessments were available in both languages.

Prior to the COVID-19 pandemic, in-person interviews were conducted at a university research laboratory. Study staff obtained informed consent from caregivers and assent from adolescents, at T1. The consent/assent process was the same at T2 for adolescents under 18 years of age. For adolescents who had turned 18 before participating in their T2 assessment, adolescent and caregiver each provided consent for their own participation in the study. Caregiver and adolescent participants were then taken to separate rooms to enhance privacy. All questionnaires were completed on a tablet, provided by study staff, and administered through REDCap (Harris et al., 2019). During the course of the study, due to constraints necessitated by the COVID-19 pandemic, study procedures were minimally altered to allow for remote assessment via the Zoom meeting platform (Banyai, 1995). Similar to in-person assessments, caregiver and adolescent remote participants completed assessment batteries in separate Zoom "break-out rooms" to enhance privacy. During both timepoints (i.e., T1, T2), each participant's (i.e., all parents, all adolescents) interview took approximately 1.5 hr to complete. Upon completion of each of the two assessment timepoints, adolescents were compensated with a $40 gift card and caregivers received a $10 gift card and $25 for travel expenses. Remote participants received identical compensation (not including travel reimbursement), though provided through electronic gift cards sent to individual email addresses. The Institutional Review Board approved all study procedures.

Measures

Demographic information

Demographic information, such as age, biological sex, race, and ethnicity, was assessed at both the first and second timepoint.

Temperament

Adolescent temperament was assessed by the child- (CR) and parent- (PR) report versions of the Early Adolescent Temperament Questionnaire Revised Short Form (EATQ-R; Ellis & Rothbart, 2001) at T1. The EATQ-R CR and PR consist of 65 and 62 items, respectively. Items on the EATQ-R CR and PR are rated on a five-point Likert scale, ranging from 1 = *almost never* to 5 = *almost always true*, and contribute to 10 and 8 temperamental subscales, respectively. The EATQ-R CR subscales are grouped under the four overarching superscales of Negative Affectivity, Surgency, Effortful Control, and Affiliativeness, whereas the EATQ-R PR contains only three of the superscales, with Affiliativeness labeled as a subscale on the PR. It should be noted that items on the Affiliativeness subscale of the EATQ-R PR do not load onto any of the other subscales or the three superscales. The present study utilized the broad-based superscales from both EATQ-R CR and PR, as well as the PR Affiliativeness subscale for assessment of temperamental dimensions and profiles of adolescent participants. Internal consistency for each of the EATQ-R CR and PR superscales and the PR Affiliativeness subscale was within acceptable range ($\alpha = .66–.86$).

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Substance use

Adolescents self-reported, at T1, whether or not they had used an e-cigarette (even one or two puffs) and/or consumed an alcoholic beverage (more than a sip) in their lifetime (i.e., dichotomous variable [yes or no] regarding lifetime use of each substance previous to T1). At T2, adolescents once again self-reported whether or not they had used an e-cigarette (even one or two puffs) and/or consumed an alcoholic beverage (more than a sip), though the question was now posed as, "since the previous assessment" (i.e., dichotomous variable [yes or no] regarding use of each substance since T1). Current statistical models included the relevant dichotomous lifetime use variable (i.e., e-cigarette or alcohol assessed at T1) as a covariate to create a baseline measure of use of the substance prior to assessment of temperament. Importantly, this covariate was included as an attempt to derive from the statistical models a proxy for early e-cigarette and/or alcohol use.

Data analytic plan

First, descriptive analyses and correlations were run to examine associations among all study variables. Path models were then estimated, whereby e-cigarette and alcohol use (i.e., during the approximately 15 months between the two assessment points; assessed at T2) was regressed on each of the temperamental dimensions (i.e., assessed at T1). Path modeling was computed using Mplus software v7.4, with the robust maximum likelihood (MLR) estimator, to address any lack of normality in the variables (Muthén & Muthén, 1998-2011). Separate models were computed for parent- and adolescent-reported temperamental dimensions.

LPA were conducted to identify distinct profiles of temperament within the study sample.[2] LPAs were first conducted with temperamental dimensions, utilizing Mplus software v7.4 with the MLR estimator (Muthén & Muthén, 1998-2011). One through five latent profiles were examined with the goal of identifying the best fitting model. Model fit was examined using the Bayesian information criterion (BIC; Schwarz, 1978), the Lo-Mendell–Rubin likelihood ratio test (LMRT; Lo et al., 2001), the bootstrapped likelihood ratio test (BLRT; McLachlan & Peel, 2000), and entropy. Profile sensitivities, profile size, and theoretical interpretation were additionally used in deciding the number of profiles to extract. Logistic regression was then utilized, through the use of SAS software v9.4 (SAS Institute, 2013), to determine whether the derived latent profiles differentially predicted adolescent use of e-cigarettes and alcohol (i.e., as assessed at T2). When more than two profiles were extracted, the profiles were dummy coded and a reference group utilized. Separate models were computed for parent- and adolescent-reported temperamental dimensions, a methodological "best practice" allowing for the examination of the separate and unique perceptions often provided by multiple informants (Achenbach, 2011; De Los Reyes et al., 2013).

For each model, lifetime use of the relevant substance (i.e., e-cigarettes – 33.3% of the T2 completed adolescent sample; alcohol – 32.2%), assessed at T1, was included as a covariate to establish a baseline measure of use, assessed at the same timepoint (i.e., T1) as the temperamental dimensions. The inclusion of the T1 lifetime use covariate coupled with the T2 outcome variable, which assessed all e-cigarette or alcohol use between timepoints (i.e., initiation and continued use; e-cigarettes – 27.4%, alcohol – 27.4% of the adolescent sample that completed T2) was utilized to provide a proxy for early e-cigarette or alcohol use. Such a proxy was developed, as frequency of pure initiation between timepoints was low (i.e., e-cigarettes – 13.0%, alcohol – 10.3% of the adolescent sample that completed T2). Biological sex, age, and ethnicity were included as additional covariates to account for factors known to influence rates of e-cigarette and alcohol use during adolescence (Kann et al., 2018).

[2]The recommended Vermunt 3-Step Method was attempted, in an effort to identify profiles and predict distal outcomes in a single model, resulting in step 3 errors (i.e., one or more profiles devoid of association with distal outcomes). As such, the analysis was completed using two models (i.e., one model to identify temperamental profiles, one model to predict distal outcomes from resulting profiles).

Results

Differential descriptive analyses

Of the 264 parent/child dyads who provided data at T1, 146 had completed the T2 assessment at the time of this study. Path models solely included data from these 146 dyads. LPA was computed utilizing data from all 264 dyads.

The 146 dyads who had completed T2 at the time of this study were compared with those who had not yet completed T2 ($n = 118$) on biological sex, ethnicity, temperamental dimensions (i.e., T1 parent and adolescent report), and lifetime use of each substance of interest (i.e., T1 lifetime e-cigarette and alcohol use). A chi-square test of independence (i.e., to examine biological sex) and multiple MANOVAs were performed to examine the relation between T2 completion status, and each assessed demographic variable. Those who had completed T2 at the time of this study were more likely to be female, $\chi^2(1, N = 264) = 16.47$, $p < .001$, and more affiliative, according to adolescent self-report [$F(1, 262) = 8.53, p < .01$]. No differences were found for ethnicity, the remaining parent- and adolescent-report derived temperamental dimensions, or T1 lifetime use of e-cigarettes or alcohol.

Descriptive analyses

Descriptive statistics of all study variables within the subsample ($n = 146$) are reported in Table 1. Of note, as outlined in Table 2, parent-reported negative affect was positively correlated with lifetime use of alcohol, as was surgency with lifetime use of e-cigarettes and affiliativeness with e-cigarette use at T2. Adolescent report of effortful control was negatively associated with all substance use variables, whereas negative affect was positively correlated with all substance use variables, with the exception of e-cigarette use at T2. Additionally, adolescent report of affiliativeness showed a positive correlation with all substance use variables, except lifetime e-cigarette use (see Table 2).

Parent-report of temperament models

Dimensions of temperament and adolescent substance use (path model)

Overall, the path model based on PR of temperamental dimensions accounted for approximately 19.4% of the variance in e-cigarette use and 34.7% of the variance in alcohol use at T2. As presented in Figure 1, e-cigarette use was significantly negatively regressed on parent-reported effortful control ($b = -.81$, $p < .05$), such that adolescents whose parents reported them to display higher levels of effortful control at the first timepoint were less likely to endorse e-cigarette use at the second timepoint. Parent-reported dimensions of adolescent temperament did not significantly predict alcohol use at T2.

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Table 1. Study variable descriptive statistics

	Mean	Standard deviation	Observed range
1. Age (T1)	14.91	0.67	14–17
2. Age (T2)	16.23	0.72	15–18
3. Biological sex	0.38	0.49	0–1
4. Ethnicity	0.83	0.38	0–1
5. Effortful control (PR)	3.48	0.63	1–5
6. Negative affect (PR)	2.27	0.59	1–5
7. Surgency (PR)	3.34	0.52	1–5
8. Affiliativeness (PR)	3.65	0.75	1–5
9. Effortful control (AR)	3.43	0.52	1–5
10. Negative affect (AR)	2.61	0.57	1–5
11. Surgency (AR)	3.24	0.57	1–5
12. Affiliativeness (AR)	3.81	0.55	1–5
13. E-cigarette use (T1)	0.32	0.47	0–1
14. Alcohol use (T1)	0.30	0.46	0–1
15. E-cigarette use (T2)	0.28	0.45	0–1
16. Alcohol use (T2)	0.28	0.45	0–1

Note. Biological sex (0 = girls, 1 = boys); Ethnicity (0 = non-Hispanic/Latinx, 1 = Hispanic/Latinx); T1 = measured at the first timepoint, T2 = measured at the second timepoint, PR = parent report, AR = adolescent report; means reported for binary (i.e., 0/1) variables indicate the proportion of cases coded 1.

Latent subgroups (LPA dimensions of temperament)

LPA was conducted, on parent-reported dimensions of adolescent temperament, to identify distinct profiles of temperament within the study sample. As shown in Table 3, the BIC-value increased after the three-profile solution, the BLRT remained significant for all five profile solutions, and the LMRT was only significant for the three-profile solution. As such, available indicators demonstrated that the three-profile solution provided the best model fit, thus this solution was chosen for further analysis. Though entropy was relatively low (i.e., 0.68), the posterior probabilities had acceptable values (i.e., above 0.85). The three-profile solution (see Figure 2 and Table 4) appeared to represent a *Reserved* profile (i.e., moderate effortful control, low negative affect, lowest surgency, lowest affiliativeness; $n = 65$, 43.9% of the T2 sample), a *Resilient* profile (i.e., high effortful control, low negative affect, high surgency, moderate affiliativeness; $n = 66$, 44.8% of the T2 sample), and an *Undercontrolled* profile (i.e., low effortful control, high negative affect, and high surgency; $n = 15$, 11.3% of the T2 sample). Of note, the temperamental pattern of the subsequently labeled Undercontrolled profile did not parallel a hypothesized profile, as provided by Hirvonen and colleagues (2018), but did resemble the Undercontrolled temperamental style found by Caspi and colleagues (2003) among 3-year-old children.

Profiles of temperament and adolescent substance use (logistic regression models)

E-cigarette use. The logistic regression model for e-cigarettes, presented in Table 5, was statistically significant, $\chi^2(6) = 19.94$, $p < .01$. The model accounted for 13% of the variance in e-cigarette use. Of particular interest, membership in the *Reserved* profile, relative to the *Resilient* profile, was associated with a decreased likelihood of e-cigarette use (odds ratio [OR] = .29, 95% CI [.12, .71], $p < .01$). There was not a significant difference in the likelihood of e-cigarette use when comparing the *Resilient* profile to the *Undercontrolled* profile.

Alcohol use. The logistic regression model for alcohol was statistically significant, $\chi^2(6) = 32.63$, $p < .01$ (see Table 5). The model accounted for 20% of the variance in alcohol use. Though the covariates of ethnicity and lifetime use of alcohol at T1 were found to reach significance in the model, profile membership was not shown to differentially predict alcohol use.

Adolescent-report of temperament models

Dimensions of temperament and adolescent substance use (path model)

Overall, the path model based on adolescent report of temperamental dimensions, presented in Figure 1, accounted for approximately 15.3% of the variance in e-cigarette use and 33.4% of the variance in alcohol use at T2. There was no evidence of temperamental variables significantly predicting e-cigarette use at T2. Alcohol use was shown to be significantly negatively regressed on effortful control ($b = -1.06$, $p = .01$), such that adolescents who reported higher levels of effortful control at the first timepoint were less likely to endorse alcohol use at the second timepoint.

Latent subgroups (LPA dimensions of temperament)

LPA was conducted on adolescent report of temperamental dimensions (i.e., assessed at T1), to identify distinct profiles of temperament within the study sample. As reported in Table 3, the BIC value increased after the two-profile solution, the BLRT remained significant for all but the five-profile solution, and the LMRT was only significant for the two-profile solution. As such, available indicators demonstrated that the two-profile solution provided the best model fit. Nonetheless, further examination of the two-profile solution revealed a rather low entropy (i.e., 0.68), as well as profiles inconsistent with theoretical work. As such, the three-profile solution ultimately appeared to provide the most parsimonious and theoretically convergent model. Entropy remained rather low (i.e., 0.65), but the posterior probabilities were acceptable (i.e., above 0.84), as was the minimum profile size (i.e., approximately 18% of the total sample). Further, the three-profile solution (see Figure 3 and Table 4) represented profiles paralleling those found by Hirvonen et al. (2018): *Mixed-type* (i.e., lowest degree of effortful control, highest degree of negative affect, lowest degree of surgency, low affiliativeness; $n = 22$, 15.1% of the T2 sample), *Average* (i.e., mean degree of each of the four assessed temperamental dimensions; $n = 99$, 67.8% of the T2 sample), and *Resilient* (i.e., highest degree of effortful control, lowest degree of negative affect, highest degree of surgency, moderate affiliativeness; $n = 25$, 17.1% of the T2 sample). A similar *Resilient* profile of temperament was extracted from the PR-based LPA ($n = 66$, 44.8% of the T2 sample). When examining the T2 profile *n*s, 15 adolescents (i.e., 10.3% of the total T2 adolescent sample) were identified as displaying a *Resilient* profile by both parent and adolescent reporters (see Table 6).

Profiles of temperament and adolescent substance use (logistic regression models)

E-cigarette use. The logistic regression model, outlined in Table 5, was statistically significant, $\chi^2(6) = 15.69$, $p < .05$. The model accounted for 10% of the variance in e-cigarette use. Though the covariate of lifetime use of e-cigarettes at T1 reached

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Table 2. Correlations for study variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Age (T2)	–														
2. Biological sex	0.01	–													
3. Ethnicity	**0.14**	−0.13	–												
4. Effortful control (PR)	−0.03	**−0.27**	0.14	–											
5. Negative affect (PR)	0.02	−0.02	**−0.15**	**−0.51**	–										
6. Surgency (PR)	−0.10	0.12	−0.09	0.13	0.01	–									
7. Affiliativeness (PR)	−0.04	**−0.16**	0.10	**0.21**	0.08	**0.41**	–								
8. Effortful control (AR)	0.04	−0.01	0.01	**0.24**	**−0.19**	0.09	0.07	–							
9. Negative affect (AR)	0.01	−0.08	−0.02	**−0.22**	**0.39**	−0.06	−0.05	**−0.43**	–						
10. Surgency (AR)	0.04	0.08	−0.07	0.06	−0.02	**0.45**	0.07	0.13	**−0.32**	–					
11. Affiliativeness (AR)	0.07	−0.10	0.01	−0.02	−0.01	0.13	0.11	**0.14**	0.12	0.10	–				
12. E-cigarette use (T1)	0.08	0.09	0.06	−0.09	0.13	**0.16**	0.05	**−0.21**	**0.16**	0.13	0.01	–			
13. Alcohol use (T1)	**0.21**	−0.03	0.11	−0.08	**0.14**	0.05	−0.03	**−0.17**	**0.19**	0.13	**0.17**	**0.31**	–		
14. E-cigarette use (T2)	0.03	−0.01	0.04	−0.13	0.09	0.12	**0.17**	**−0.22**	0.12	0.09	**0.14**	**0.25**	0.11	–	
15. Alcohol use (T2)	0.06	−0.07	**0.19**	−0.03	0.10	−0.02	0.04	**−0.20**	**0.20**	0.04	**0.19**	**0.27**	**0.38**	**0.22**	–

Note. Biological sex (0 = girls, 1 = boys); Ethnicity (0 = non-Hispanic/Latinx, 1 = Hispanic/Latinx); PR = parent report; AR = adolescent report; E-cigarette use/Alcohol use (0 = No, 1 = Yes); T1 = lifetime use, measured at the first timepoint; T2 = measured at the second timepoint; SD = standard deviation; bold values = significant correlations ($p < .05$).

significance in the model, profile membership was not shown to differentially predict e-cigarette use (Table 5).

Alcohol use. The model was statistically significant, $\chi^2(6) = 38.00$, $p < .01$ (see Table 5). The model accounted for 23% of the variance in alcohol use. Importantly, as shown in Table 5, membership in the *Mixed-type* profile, relative to the *Resilient* profile, was associated with a markedly increased likelihood of alcohol use (OR = 7.05, 95% CI [1.17, 42.49], $p < .05$). There was not a significant difference in the likelihood of alcohol use when comparing the *Average* profile to the *Resilient* profile.

Discussion

This study was an examination of early e-cigarette and alcohol use outcomes among an adolescent population (i.e., Latinx youth) previously shown to be at particular risk for early use of e-cigarettes and alcohol (Kann et al., 2018). Study aims included extraction and identification of *profiles* of temperament (e.g., Undercontrolled, Average, Resilient, Mixed-type; Hirvonen et al., 2018) that were hypothesized to characterize subgroups of adolescents. The study utilized the psychobiological model of temperament (Rothbart & Derryberry, 1981), through employment of a multiple-informant methodology, which allowed for potentially divergent and unique viewpoints with regard to adolescent temperament (Boson et al., 2018). It was posited that if temperamentally differentiated groups could be successfully extracted from within this sample, they would be further characterized by differing vulnerability for early use of e-cigarettes and alcohol. Moreover, the predictive ability of singular dimensions of temperament (i.e., negative affect, surgency, effortful control, affiliativeness) with respect to early use of e-cigarette and alcohol use was additionally examined utilizing path modeling across both parent- and adolescent-reports of temperament.

Parent-report of temperament

Path models based on PRs showed effortful control to be the only significant predictor (protective against) of adolescent e-cigarette use. Though the implication of effortful control in protection against adolescent e-cigarette use converges well with prior work (Hoffmann et al., 2017), the lack of association between affiliativeness and e-cigarette use is of interest, as prior work has extolled the importance of social motivations to the initiation and early use of e-cigarettes among adolescents (Kann et al., 2018; Kong et al., 2021). Though this study did find parent-reported affiliativeness to be positively correlated with adolescent use of e-cigarettes, it is clear that within the present sample the singular temperamental dimension of effortful control provided greater indication of adolescent e-cigarette use. It may be that when considered in isolation, the temperamental dimension of affiliativeness (i.e., tendency to react with concern for others and a desire for interpersonal closeness) does not fully provide the temperamental basis for sociability. It could be that the temperamental dimensions of affiliativeness *and* surgency (i.e., the prosocial dimensions; Eisenberg et al., 2009) must be considered in tandem to understand an adolescent's level of sociability. Another consideration is that the unique make-up (i.e., of largely Latinx ethnicity) of this study sample may have provided for the significant association between parent-reported effortful control and lower adolescent use of e-cigarettes. Prior work has shown Latinx youth to be higher in effortful control than their non-Latinx, white peers as based on PR of temperament. It was further posited that this may be due to a strong cultural emphasis on obedience and self-control among Latin American families (Farkas & Vallotton, 2016). It may then follow that teens, whose behaviors and peer groups would be less likely to include e-cigarette use, would be rated higher in effortful control by their parents; thus, indirectly influencing the relationship between this temperamental dimension and adolescent e-cigarette use. Interestingly, though previous work has often found associations between use of alcohol and several of the

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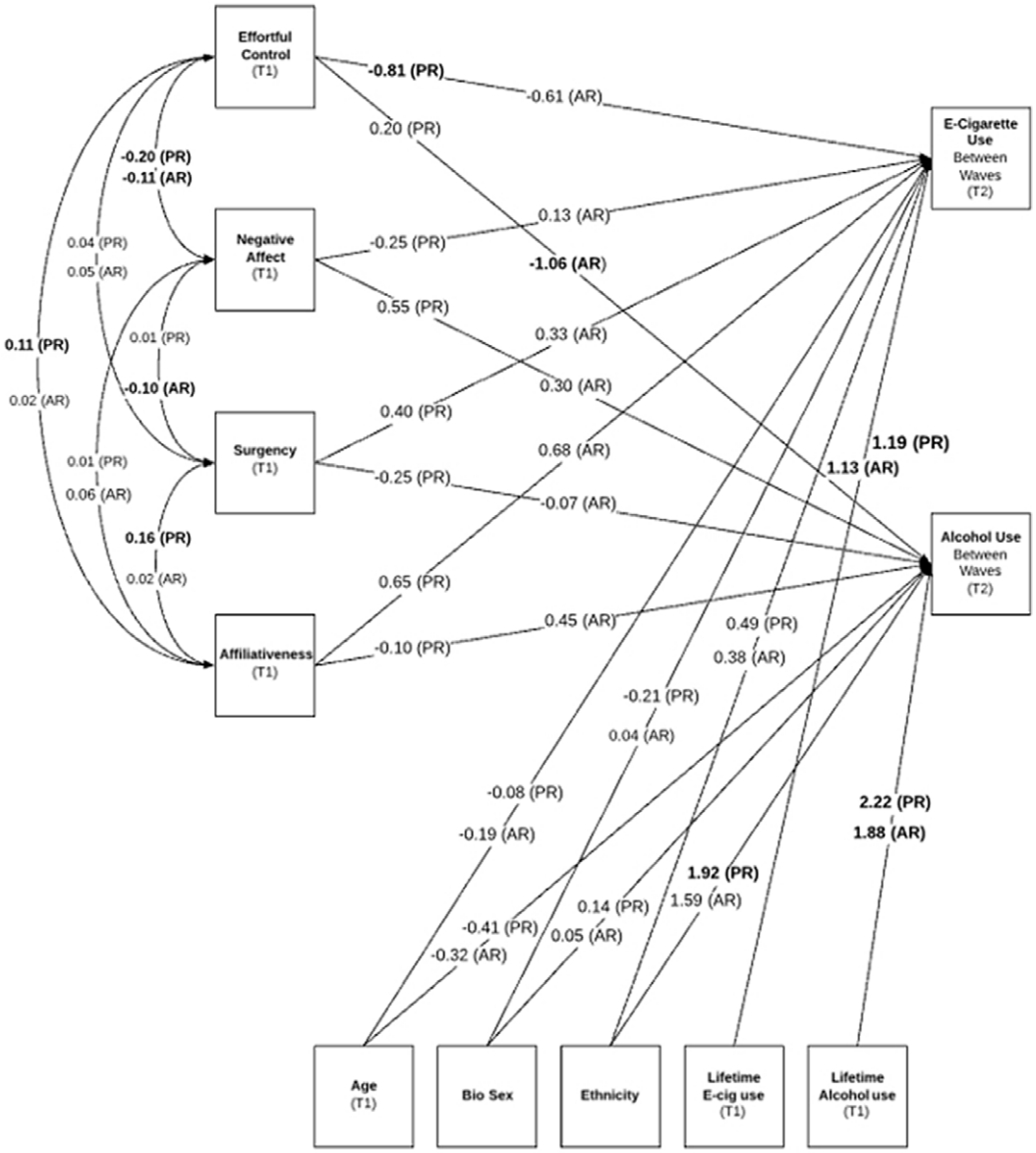

Figure 1. Path models: Parent- and adolescent-reported dimensions of temperament. Unstandardized data presented; bold data represents significant values ($p < .05$); T1 = measured at first timepoint; E-cigarette/alcohol use between timepoints (0 = No, 1 = Yes); T2 = measured at second timepoint; AR = adolescent report; PR = parent report.

assessed dimensions of temperament (e.g., negative affect – O'Hara et al., 2020; effortful control and surgency – Scalco et al., 2021), current findings showed no temperamental dimensions to be significantly predictive of early use of alcohol. It is possible that alcohol use within the current sample was not significantly or differentially associated with any specific dimensions of temperament, thus diverging from these previous findings. Perhaps more likely is that temperamental predictors of early alcohol use in the present sample may be dimensions of temperament that were less accurately rated by parent participants. For example, it has been theorized that the cognitions, affect, and behaviors which are influenced by negative affectivity are often experienced by youth to a differing degree than they are externally displayed (Kopala-Sibley et al., 2018). As such, parents may have more difficulty accurately assessing these temperamental dimensions for their child.

LPA models based on PR revealed three temperamental profiles. As hypothesized, a profile group characterized by moderate effortful control, relatively low negative affect, low surgency and low affiliativeness, thus resembling Hirvonen and colleagues' (2018) Reserved profile (i.e., moderate to high effortful control, low negative affect, low surgency, low to moderate affiliativeness) was extracted. Next, a profile group temperamentally parallel to Hirvonen and colleagues' Resilient group, populated by positively oriented, behaviorally controlled, and highly prosocial individuals (i.e., high effortful control, minimal negative affect, moderate surgency and affiliativeness) emerged. Finally, a temperamental pattern was extracted which did not resemble a profile found by Hirvonen and colleagues. This temperamental profile was characterized by low effortful control, high negative affect, high surgency, and high affiliativeness. Upon further review of the extant temperament literature, it was discovered that Caspi

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Table 3. Characteristics of temperamental profiles

	Parent-rated profiles			Adolescent-rated profiles		
	Inhibited	Undercontrolled	Resilient	Mixed	Average	Resilient
Profile *n* (% *N* [*N* = 146])	65 (43.9%)	15 (11.3%)	66 (44.8%)	22 (15.1%)	99 (67.8%)	25 (17.1%)
Convergence across raters (# of individuals, % of profile)			15 (22.7%)			15 (60.0%)
Effortful control (*M*)	3.30	2.64	3.84	3.08	3.36	4.04
Negative affect (*M*)	2.28	3.41	2.01	3.48	2.61	1.84
Surgency (*M*)	2.95	3.51	3.68	2.94	3.23	3.58
Affiliativeness (*M*)	3.16	4.03	4.07	4.05	3.75	3.84
*M*age/*SD* at T1	15.09 (.68)	15.13 (.83)	14.85 (.71)	14.86 (.56)	15.03 (.73)	14.92 (.76)
*M*age/*SD* at T2	16.31 (.71)	16.33 (.72)	16.12 (.73)	16.09 (.61)	16.27 (.73)	16.2 (.80)
Female	34 (52.3%)	9 (60.0%)	48 (72.7%)	13 (59.1%)	62 (62.6%)	16 (64.0%)
Latinx	56 (86.2%)	10 (66.7%)	55 (83.3%)	18 (81.8%)	85 (85.9%)	18 (72.0%)
			ECIG			
No lifetime use at T1	48 (73.8%)	8 (53.3%)	48 (72.7%)	11 (50.0%)	67 (67.7%)	22 (88.0%)
Use between T1 and T2	11 (16.9%)	3 (20.0%)	26 (39.4%)	8 (36.4%)	30 (30.3%)	2 (8.0%)
Initiation between T1 and T2 (% *N*)	5 (7.7%)	0 (0.0%)	14 (21.2%)	3 (13.6%)	14 (14.1%)	2 (8.0%)
			ALCOHOL			
No lifetime use at T1	44 (67.7%)	9 (60.0%)	48 (72.7%)	13 (59.1%)	67 (67.7%)	21 (84.0%)
Use between T1 and T2	19 (29.2%)	3 (20.0%)	18 (27.3%)	10 (45.5%)	28 (28.3%)	2 (8.0%)
Initiation between T1 and T2 (% *N*)	6 (9.2%)	1 (6.7%)	8 (12.1%)	5 (22.7%)	9 (9.1%)	1 (4.0%)

Note. *M* = mean; *N* = sample size at second timepoint; *SD* = standard deviation; T1 = measured at the first timepoint; T2 = measured at the second timepoint.

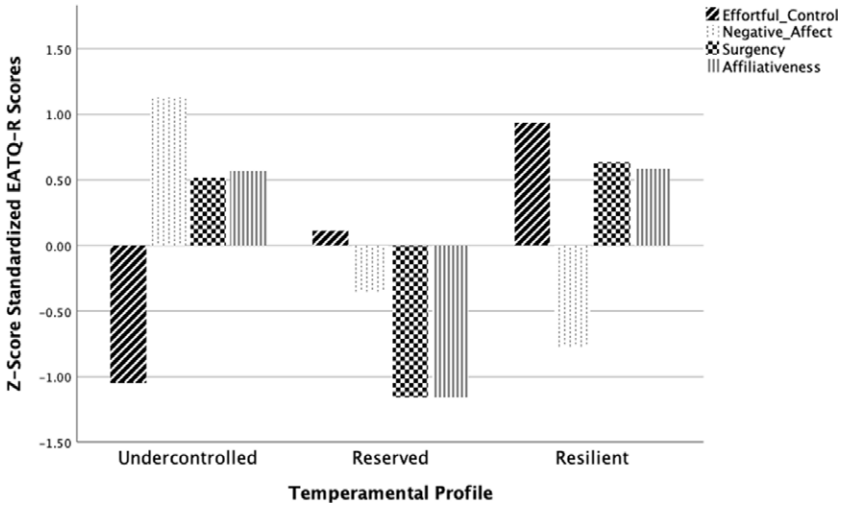

Figure 2. Parent-reported EATQ-R scores by temperamental dimension and latent profile.

and colleagues (2003) had identified a similarly characterized (i.e., low effortful control, high negative affect, high surgency) group, albeit with young children. This group was subsequently labeled as Undercontrolled, in explanation of the problematic arousal and valence characteristic of the typology, coupled with the lack of effortful control.

The LPA/logistic regression models tell a slightly different story compared to those provided by singular temperamental dimensions. While the path model indicated increased effortful control to predict a lower probability of e-cigarette use during adolescence, the LPA/logistic regression models indicated increased levels of effortful control to provide a slight *risk* for e-cigarette use during adolescence (i.e., membership in the Resilient profile with higher levels of effortful control showed greater odds of use than membership in the Reserved profile). Though it is possible that the statistical models simply tell different stories, it is potentially more likely that the *risk* provided by a Resilient temperament (i.e., profile) relative to a Reserved temperament (i.e., profile) is greater than the *protection* provided by the profile's characteristically higher level of effortful control with regard to use of e-cigarettes. Previous literature showing shy and socially anxious adolescents (e.g., those displaying a Reserved temperamental profile) to have markedly lower rates of substance use during adolescence than counterparts with good interpersonal capabilities (e.g., those displaying a

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Table 4. Model fit values for five latent profile models

Profile	BIC	BLRT	LMRT	Entropy	Posterior prob.	Profile size
Parent-report of temperament						
1	2000.95	–	–	–	–	264
2	1957.81	0	0.27	0.75	0.85	49
3	1919.67	0	0.01	0.68	0.85	28
4	1924.93	0.05	0.2	0.73	0.83	9
5	1920.93	0	0.12	0.79	0.85	8
Adolescent-report of temperament						
1	1700.23	–	–	–	–	264
2	1658.13	0	0.02	0.58	0.83	91
3	1662.80	0	0.33	0.65	0.84	47
4	1672.99	0.05	0.25	0.76	0.82	6
5	1687.24	0.15	0.31	0.76	0.80	4

Note. BIC = Bayesian information criterion; BLRT = bootstrap likelihood ratio test; LMRT = Lo-Mendell–Rubin likelihood ratio test; Posterior prob. = minimum posterior probability within the model; Profile size = minimum profile size within the model.

Table 5. Logistic regression models predicting E-cigarette and alcohol use at second timepoint

	E-Cigarette models				Alcohol models			
	Parent-report models							
	b	*SE*	*p*	OR	*b*	*SE*	*p*	OR
Intercept	−2.37	4.27	.58	–	1.92	4.56	.67	–
Age	.07	.29	.80	1.07	−.35	.31	.27	.71
Sex	.19	.43	.65	1.21	.01	.47	.98	1.01
Ethnicity	.45	.59	.44	1.57	**1.67**	**.84**	**.05**	**5.32**
Lifetime use	**1.28**	**.41**	**<.01**	**3.58**	**2.15**	**.46**	**<.01**	**8.62**
Undercontrolled vs Resilient	−1.20	.76	.12	.30	−.21	.85	.80	.81
Reserved vs Resilient	**−1.23**	**.46**	**.01**	**.29**	.02	.47	.97	1.02
	Adolescent-report models							
	b	*SE*	*p*	OR	*b*	*SE*	*p*	OR
Intercept	−.92	4.22	.83	–	−.09	4.72	.99	–
Age	−.13	.28	.65	.88	−.29	.32	.35	.75
Sex	−.13	.42	.76	.88	−.04	.46	.94	.97
Ethnicity	.27	.58	.64	1.32	**1.79**	**.88**	**.04**	**6.00**
Lifetime use	**1.13**	**.41**	**.01**	**3.10**	**2.04**	**.46**	**<.01**	**7.71**
Mixed-type vs Resilient	1.45	.89	.10	4.25	**1.95**	**.92**	**.03**	**7.05**
Average vs Resilient	1.39	.78	.08	4.01	1.16	.81	.15	3.20

Note. Sex = Biological sex (0 = Female, 1 = Male); Ethnicity (0 = Non-Hispanic/Latinx, 1 = Hispanic/Latinx); Lifetime use (measured at first timepoint; 0 = No, 1 = Yes); *b* = estimate; *SE* = standard error; *p* = significance; OR = odds ratio; bold data/values represent significant predictors ($p < .05$).

Resilient temperamental profile; Lemyre et al., 2019) supports this position. It is posited that such Reserved individuals may choose not to place themselves in social settings where the opportunities to use substances are more plentiful as compared to those with Resilient profiles characterized by high levels of interpersonal (i.e., social) capabilities. This explanation may be particularly relevant to the use of e-cigarettes among adolescents, which has been repeatedly found to be highly socially motivated and oriented (Kann et al., 2018; Kong et al., 2021). Still, the present study did fail to find a significant protective association between the Reserved profile of temperament and alcohol use during adolescence, an interesting finding in light of previous research showing early use of alcohol to be highly socially motivated as well (Dumas et al., 2019). Though no clear explanation has emerged for this lack of association, it does highlight the relative strength of the current associations between sociability and adolescent e-cigarette use. Present findings suggest that *profiles* of temperament are much more than "a list of unrelated [temperamental] traits" (Rothbart, 2007).

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Table 6. Cross-referenced parent- and adolescent-reported profiles

	Undercontrolled (PR; $n = 15$)	Reserved (PR; $n = 65$)	Resilient (PR; $n = 66$)
Mixed-type (AR; $n = 22$)	6	10	6
Average (AR; $n = 99$)	9	45	45
Resilient (AR; $n = 25$)	0	10	15

Note. AR = adolescent-reported; n = profile sample size; PR = parent-reported.

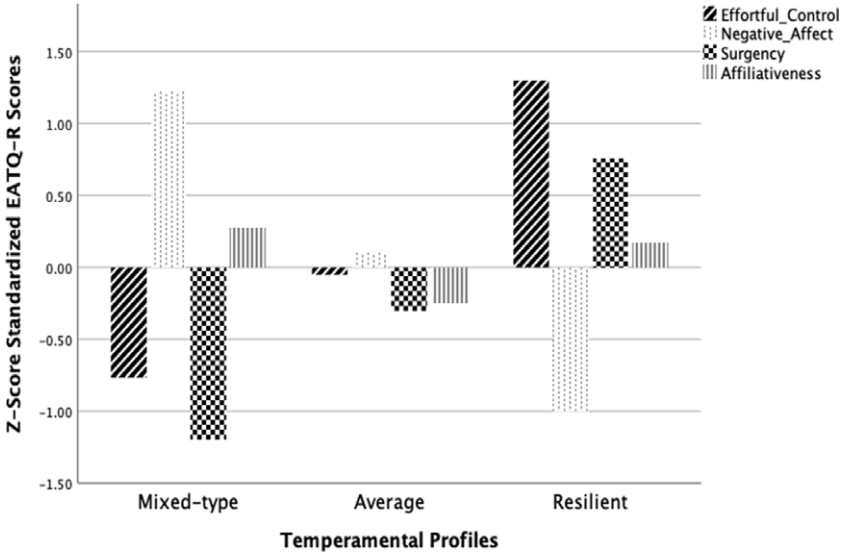

Figure 3. Adolescent-reported EATQ-R scores by temperamental dimension and latent profile.

Adolescent-report of temperament

Similar to results from PR models, though adolescent-reported dimensions of temperament revealed no significant predictive ability with regard to e-cigarette use, effortful control did emerge as the sole dimension of temperament to significantly predict alcohol use. Although the protective role of effortful control on alcohol use is unsurprising given prior work (Peeters et al., 2017), it is of note that neither e-cigarette nor alcohol use were significantly regressed upon affiliativeness, though extant work has found use of both substances to be highly socially motivated during adolescence (Kirkpatrick et al., 2021; Kong et al., 2021). Again, this may relate to the importance of examining the prosocial temperamental dimensions of surgency and affiliativeness in tandem and/or differences specific to this largely Latinx sample of youth as detailed above.

Three temperamental profiles were also revealed through LPA models based on adolescent-report. As expected, Hirvonen colleagues' (2018) Mixed-type profile, characterized by low effortful control, high negative affect, low surgency, and moderate affiliativeness emerged. As hypothesized, a second profile was extracted, which was populated by a group of adolescents displaying mean levels of all assessed temperamental dimensions, thus being defined by Hirvonen and colleagues as of Average temperament. Finally, a Resilient group of highly prosocial youth with optimal levels of self-control, yet again emerged.

Profiles based on adolescent-report of temperament and related use resulted in significant differential risk for adolescent alcohol use. Findings indicate that adolescents characterized by a Mixed-type profile of temperament had significantly higher odds (i.e., seven times greater) of alcohol use than those characterized as Resilient. Though differential risk for alcohol use may simply be explained by each profile's characteristic level of effortful control, mirroring the finding from the adolescent-report-based path model, the magnitude of this effect supports a more complex association. To this end, a close examination of the make-up of the Mixed-type and Resilient profiles reveals, beyond differing levels of effortful control, a notable difference in levels of negative affect, with the Resilient profile characterized by much lower levels of the dimension than is the Mixed-type profile. Further, there is a clear difference in levels of surgency, indicative of positive affect, which may provide additional differential predictive ability between the profiles (Fairlie et al., 2019). Still, though potentially relevant to differential risk for use, these differences in individual levels of singular temperamental dimensions do not speak to the potentially important synergistic effects between these dimensions (Farkas & Vallotton, 2016; Krieger et al., 2019).

Results of the present study highlight differences between parent- and adolescent-reports of temperament, and subsequently extracted temperamental profiles. Though effort control proved to be the sole individual dimension of temperament to significantly protect against (i.e., predict) adolescent substance use, it was related to e-cigarette use in the PR model, whereas it was related to alcohol use in the adolescent-report model. Interestingly, mean levels of effortful control between reporters is quite similar, as provided in Table 1. Highly divergent rankings of effortful control between dyad informants (i.e., parent and adolescent) may explain similar mean levels of the dimension between reporters across the sample and yet differing predictive qualities by reporter. Moreover, what adolescents display or parents perceive (i.e., PR) with regard to the regulative aspect of temperament (i.e., effortful control) likely differs from what adolescents perceive to be their own (i.e., adolescent self-report) capabilities of self-regulation

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(i.e., effortful control). It is important to note that although mean levels of all four temperamental dimensions (see Table 1) were similar across reporters, the temperament profiles that emerged were different between reporters for two of the three profiles. The singular similar temperamental pattern to emerge from within both the parent- and adolescent-report-based models was the Resilient profile, with only 10.3% ($n = 15$; see Table 6) of adolescents categorized as Resilient by both parents and adolescents. This too suggests that what adolescents display, or their parents perceive them to display, and what adolescents perceive with regard to their own reactive and regulative capacities (i.e., temperament) is, at least in part, different. It may be, as hypothesized by Latham and colleagues (2020), that self-report becomes a more viable method of assessment at this age, with parents becoming less accurate reporters and adolescents becoming more reliable reporters of their emotions and behaviors. It is equally possible that different informants will always provide differing though equally accurate reports of temperament as they are viewing reactions and regulation from differing vantage points.

Clinical implications

Although these findings are in need of replication, they do provide some potential clinical implications with regard to the assessment and identification of those adolescents for which services may be highly beneficial, particularly within the Latinx community. They suggest that classifying adolescents by temperament may be of use in the identification of those individuals at elevated risk for early use of specific substances (e.g., e-cigarettes, alcohol). Further, current findings suggest that adolescent substance use assessment and programing may be best served by including assessment of profiles of temperament when examining temperamental vulnerability for early use. The additional examination of comprehensive profiles of adolescent temperament may increase the effectiveness of relevant assessment and programing by accounting for interactions that may occur between temperamental dimensions within the adolescent, thereby providing potentially more nuanced information regarding use among vulnerable individuals. Moreover, temperamental profiles identify subgroups of individuals from within a larger group who share similar patterns of temperament. Further, present findings suggest that profiles of temperament may be characterized by differential vulnerability for specific substance use. In theory, prevention programing could then be prioritized for adolescents displaying a vulnerable profile type (e.g., Mixed-type). This may potentially provide such programing with a greater level of efficiency and effectivity.

Limitations

This study presents evidence of the unique predictive ability of profiles of temperament with regard to early e-cigarette and alcohol use; however, there are several limitations that should be addressed. First, though the sample is representative of the population from whence it came (i.e., high school students living in South Florida) and was thoughtfully recruited to allow for specific examination of a potentially e-cigarette vulnerable subset of adolescents (i.e., Latinx), the race and ethnicity of the sample was primarily White (87.36%) and Latinx (83.98%). This unique racial and ethnic makeup may limit generalizability of findings. Future research would benefit from a more heterogenous sample with regard to race and ethnicity. Similarly, as a result of study methods, participants represented a mid- to late-adolescent age range (i.e., 14–19, including T1 and T2). It is posited that a focus on early adulthood could allow for meaningful examination of problematic use, which is typically later emerging. Effectively, a sample characterized by greater variance in severity of use among participants would allow for examinations of problematic use, variability in frequency and/or quantity of use over time, and consequences arising from use, whereas the low variance in severity of use among the present sample, though developmentally typical of the examined age group, solely allowed for an examination of early e-cigarette and alcohol use (i.e., yes or no). Relatedly, as it was found that many of the high-school freshmen and sophomores completing the T1 assessment ($N = 264$) during the present study had previously initiated use of e-cigarettes ($n = 88$, 33.3%) and alcohol ($n = 85$, 32.2%), the present study utilized a statistical proxy for early use of the assessed substances. Future work may find benefit in recruiting a younger and/or substance use naïve sample to allow for a clearer picture of substance use initiation.

Lastly, though the Cronbach's alphas of all utilized EATQ-R CR and PR superscales and the Affiliativeness subscale were within acceptable range ($\alpha = .66–.86$), both EATQ-R CR and PR Surgency superscales had an alpha slightly below threshold ($\alpha = .66$ and .67, respectively). It has been noted that, for the purpose of basic analysis, a minimum Cronbach's alpha should be .70, with the preferred range being closer to .80 (Nunnally, 1978). As the current sample is largely comprised of Latinx individuals, it is possible that the Surgency superscale is slightly less reliable for assessment within this demographic. Such a position has been offered within prior work with regard to this superscale (Clark et al., 2015). It would be beneficial to examine the reliability of this superscale, perhaps through the use of cognitive interviews, to assess its utility and reliability with regard to a Latinx sample.

Conclusions and future directions

Novel findings from this study may provide unique insight regarding the influence of temperamental differences on vulnerability for early e-cigarette and alcohol use. Importantly, current results suggest that dimensions of an adolescent's temperament may combine and interact in meaningful ways, creating a profile of temperament for each individual. Such profiles have subsequently been shown to exhibit differential vulnerability to e-cigarette and alcohol use. For example, current findings show that membership in the parent-reported Reserved profile provides protection against early e-cigarette use when compared to membership in the parent-reported Resilient group, and that adolescents self-characterized by a Mixed-type profile of temperament are particularly vulnerable to early use of alcohol when compared to their peers who self-characterize as possessing a Resilient profile. Current findings have been offered in the hope that profile-informed work on temperamental differences will continue to further elucidate the etiology of early substance use among distinctly vulnerable subgroups of adolescents.

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