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Dysregulated Emotion and Trying Substances in Childhood: Insights from a Large Nationally Representative Cohort Study

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ABSTRACT

Objective: Transdiagnostic perspectives on the shared origins of mental illness posit that dysregulated emotion may represent a key driving force behind multiple forms of psychopathology, including substance use disorders. The present study examined whether a link between dysregulated emotion and trying illicit substances could be observed in childhood. *Method:* In a large (N=7,418) nationally representative sample of children (M_{age} = 9.9), individual differences in emotion dysregulation were indexed using child and parent reports of frequency of children's emotional outbursts, as well as children's performance on the emotional N-Back task. Two latent variables, derived from either parental/child-report or performance-based indicators, were evaluated as predictors of having ever tried alcohol, tobacco, or marijuana. *Results:* Results showed that reports of dysregulated emotion were linked to a greater likelihood of trying both alcohol and tobacco products. These findings were also present when controlling for individual differences in executive control and socioeconomic status. *Conclusions:* These results suggest that well-established links between dysregulated negative emotion and substance use may emerge as early as in childhood and also suggest that children who experience excessive episodes of uncontrollable negative emotion may be at greater risk for trying substances early in life.

KEYWORDS
Emotional dysregulation; negative emotionality; substance use; trying substances; child development

Substance use presents a significant challenge globally, both socially and in terms of public health and economics (Jones, Mack, & Paulozzi, 2013; World Health Organization, 2018). In the United States, for instance, alcohol-related deaths account for a shocking 9.8% of all deaths, as noted by Kranzler and Soyka (2018). Additionally, the World Health Organization reported a 47% increase in the number of deaths worldwide due to drug abuse disorders between 2000 and 2016. These findings highlight the urgent need for increased scientific attention to address the critical public health challenge of substance abuse.

One potentially efficient approach for combating substance abuse in adulthood could be to enhance our understanding of the causes and conditions under which key substance abuse risk factors emerge early in life (Stanis & Andersen, 2014; Afuseh et al., 2020). A better understanding of how and when substance use risk factors emerge could potentiate more effective early-life intervention. One such risk factor is substance experimentation. Early-life substance experimentation has been one of the more robust predictors of substance abuse later in life (Substance Abuse and Mental Health Services Administration, 2015; Grant & Dawson, 1997). In a recent study, for example, Gustavson et al., (2017) reported an r = .44 correlation between the number of different substances a given youth had tried with and the emergence of dependence symptoms later in life (Gustavson et al., 2017). Such data should underscore the importance of understanding early-life mechanisms that may contribute to youths trying substances such as alcohol, tobacco, or other drugs.

In particular, we propose that a more precise knowledge of the factors that covary with, and that may influence, a tendency to try substances in early life should enhance our ability to detect, prevent, and mitigate substance abuse behavior early life, before the behavior has a chance to ruin lives (Moss, Chen, & Yi, 2014; Afuseh et al., 2020). In seeking to identify such factors that may presage substance trying early in life, it is reasonable to first examine the most significant factors that are thought to influence substance use in *adulthood*. In this domain, dysregulated negative emotion, which can be conceptualized as the experience of excessive and frequent negative emotion episodes, has received increasing attention as a transdiagnostic factor underlying the development and maintenance of substance abuse disorders (Cheetham et al., 2010; McHugh & Kneeland, 2019), as well myriad other forms of psychopathology (see, for example, Barlow et al., 2014).

Such findings are consistent with self-medication theories of substance use, which argue that individuals typically abuse substances in an attempt (at least initially) to cope with emotional distress (Khantzian, 1987; Stewart, 1996; Turner et al., 2018). Critically, such processes have also been evident

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in youth. For instance, substance use in teens has been mediated by a belief that substance consumption (e.g., smoking cigarettes) may reduce negative emotions (Miller et al., 2017). Relatedly, previous research has also shown that a desire to escape negative feelings has mediated substance use as early as elementary school (Wills, Sandy, & Yaeger, 2001). From this perspective, dysregulated negative emotion in childhood may constitute an important factor underlying a tendency to try different substances early in life; the present investigation examined this question.

The present investigation

Using a large nationally representative sample of children (M_{age} = 9.9) drawn from the Adolescent Brain Cognitive Development study (ABCD), the present study examines cross-sectional associations between dysregulated emotion and substance trying, with the latter specifically in the form of trying alcohol, trying marijuana, and trying tobacco. Dysregulated emotion was operationalized using two distinct behavioral (i.e., directly observable) indicators of experiencing high-arousal negative emotion. Such a behavioral measurement approach, as opposed to a subjective one, was selected for several reasons. First, subjective self-reports obtained from children have important limitations, such children's inability to understand or remember specific negative emotional experiences. Second, emotional experiences are inherently subjective and cannot be verified by parent informants. Together, these factors make measuring emotional experiences in children uncommonly difficult, and one established way to address this challenge is to use multiple measurement approaches (Zeman et al., 2007). Thus, to operationalize dysregulated negative emotion in children, we first calculated a latent negative emotion factor based on the jointly (parent and child) reported frequency of intense emotional outbursts exhibited by the child. Such incidents were considered optimal because they are both memorable and quite observable indicators of dysregulated negative emotion episodes.

Second, we also selected a performance-based indicator of emotion dysregulation referred to as the emotional n-back (ENBACK). The ENBACK is the emotion-related variant of the classic n-back attentional control task (Ladouceur et al., 2009). The ENBACK displays images of emotional faces that have been shown to engage frontal neurological circuits implicated in negative and positive emotion generation (Gee et al., 2013; Hare et al., 2008; Somerville et al., 2011) and is thought to index cognitive/attentional processes relevant to emotion management (e.g., Bertocci et al., 2012; Ladouceur et al., 2009; Schmeichel et al., 2008). For example, better ENBACK performance has been associated with an increased ability to attend to and successfully down-regulate intense emotional episodes (Schmeichel et al., 2008). Importantly, ENBACK performance has also been predictive of substance use difficulties (Caldwell et al., 2005; Squeglia et al., 2011; Tapert et al., 2001, 2004), and the task is thought to be developmentally appropriate for children (Barch et al., 2013).

We hypothesized that both self-reported and cognitive indicators of dysregulated negative emotion would predict greater frequencies of trying alcohol, tobacco, and marijuana in the present data.

Importantly, generalized performance on cognitive tasks such as the n-back, Stroop, and flanker are thought to index attentional control process (e.g., working memory) that enable successful self-regulation such as the ability to enact goal-directed behavior in a chaotic environment (Hofmann et al., 2012). Relevant to the present hypothesis, the existing literature indicates that standard n-back performance reflects self-regulation parameters (e.g., working memory) that have been specifically linked to difficulties with substance use in adults (e.g., Verdejo-Garcia et al., 2006). Along these lines, deficient executive function and self-regulation in adolescents have been linked to earlier age onset of substance use disorder (Tarter et al., 2003). From such a perspective, addictive behavior may not only be a product of emotional dysregulation but may also be also influenced by failures in self-regulation more broadly (Verdejo-Garcia et al., 2006).

Consistent with this self-regulatory perspective, substance use has been associated with dysfunction in the prefrontal cortex (Garavan & Stout, 2005), which is thought to support both self-regulation (Roberts et al., 1998; Stuss & Knight, 2002) and emotional regulation (Bechara et al., 2000; Davidson, 2002). Thus, in an exploratory hypothesis, this work examined whether individual differences in self-regulatory processes (as assessed by the classic n-back) would predict trying substances in children, and whether the previous dysregulated emotion latent factor would continue to predict trying substances after controlling for such individual differences.

In a final consideration, elements of the family environment encompassed by socio-economic status (SES) are known to impact early life substance use (Rudolph et al., 2019). For instance, SES has been predictive of an array of relevant environmental features such as parental support and monitoring (Cooper et al., 2010), the likelihood of being raised by a single parent (Conger, Conger, & Martin, 2010), or the number of peers who engage in trying substances (Ennett et al., 1997). Importantly, childhood SES has also been associated with dysregulated emotion and behavior in youths. Thus, to rule out SES as an alternative explanation for the links between dysregulated emotion and trying substances in childhood, the present models control for SES, as well as race, gender, and age of the child.

Methods

Participants and general procedures

This study examined cross-sectional baseline data (first visit only) drawn from the Adolescent Brain Cognitive Development (ABCD) study collected between 2016 and 2018 (Garavan et al., 2018). The ABCD study is an ongoing developmental project focusing on a nationally representative American youths aged 9 to 11 years (N = 7,418, M_{age} = 9.9, 47.9% female, 63.3% white, 15.7% African American, 7.2% Asian, 12.4% multiple race, and 1.3% other race). Roughly 99% of percent of the children were aged 9 or 10, and 1,720 were twins.

Although we recognize the limitations associated with examining developmentally relevant processes in the present cross-sectional dataset, the primary goal of this work was to examine the correlates of trying substances as *early in life as possible*. Thus, our optimal dependent variable was assessed at baseline age only.

The present data was collected across 21 sites in the United States. Recruitment procedures were designed to obtain a sample that closely approximates the national population demographics averages related to ethnicity, SES, sex, race, and neighborhood characteristics. Participants were primarily recruited from elementary schools. Approximately 10% of the sample, however, was obtained using other strategies, such as referrals from the current sample, outreach to community activity groups, and publicly available mailing lists. For additional information about the ABCD project methods and study design, see abcdstudy.org or Garavan et al. (2018). Further details on the sample, as well as measure and compensation information, have been previously published (Barch et al., 2018; Luciana et al., 2018). All participants agreed to take part in the study and informed consent was obtained from legal guardians. All procedures received ethical approval from the relevant local review boards.

Measures

Dysregulated negative emotion self report

A latent factor was created using two binary explosive irritability items obtained from the Kiddy Schedule for Affective Disorders and Schizophrenia DSM-5 (KSADS-5). The KSADS-5 is a well-validated semi-structured interview administered simultaneously to parents and children that is coded by trained professionals (Barch et al., 2018). To obtain a behavioral indicator of dysregulated negative emotion in children, we examined two binary items coded by interviewers that indicated whether the child (i) had recently experienced explosive irritability episodes (0 = "not present" or "not at all or less than once a week", 1 = "more days than not [4-7 days/week]" or "most of the day [at least 50% of awake time]"), and (ii) had *ever* experienced explosive irritability of this type. These items were coded by reviewing both parents' and children's responses to several questions related to episodes of emotional outbursts (e.g., "was there ever a time you were so irritable and angry that you exploded?", "when you are feeling really angry, do you throw things or break things? Tear your room apart?"). Base rates for these binary items were as follows: recent irritability $M = 1.11\%$, SD = 10.49%, previous irritability $M = 5.90\%$, SD = 23.56%.

Dysregulated emotion task performance

To incorporate a performance-based indicator of dysregulated emotion, the authors examined children's scores on the Emotional N-back task (ENBACK). ENBACK task performance is thought to index the extent to which children react to emotional provocative stimuli (Casey et al., 2018). Importantly, ENBACK performance among youth has been linked to increased depression, anxiety, and comorbid depression and anxiety (Ladouceur et al., 2005; 2009).

On each of 160 ENBACK trials, children indicated whether a number presented in the center of the screen was the same or different from a target number. Each number was flanked by identical images of human faces displaying either pleasant (happy), unpleasant (fearful), or neutral emotions (Ladouceur et al., 2009). Each trial incorporated two randomly selected (without replacement) conditions: (i) the valence of the face distractor images ("valence") and (ii) working memory load ("load"). On high load trials, children reported whether the stimulus was different from the stimulus that was presented two trials "back". On low load trials, children reported whether the stimulus was the same or different from a fixed number that did not change during the task. Each trial was coded as either correct or incorrect, and subsequent accuracy rates (78.48%) were quite similar to ENBACK results presented elsewhere (e.g., Bertocci et al., 2012).

To verify that the current ENBACK task was indexing the extent to which emotional faces (relative to neutral faces) dysregulated task accuracy, preliminary analyses revealed that face valence significantly affected performance accuracy [$F(1.65, 13233.9) = 1160.18$, $p < .001$, ges = .064], and pairwise follow-ups showed that accuracy during both positive ($M = 84.03\%$) and negative faces ($M = 83.19\%$) was significantly (all p-adj < .001) worse than during neutral faces ($M = 84.29\%$).

Following the literature, individual differences in emotion dysregulation were defined as the extent to which these positive or negative faces (relative to neutral faces) modulated children's response accuracy (Casey et al., 2018). To operationalize such an effect, two difference scores were calculated for each participant: a positive face effect (PFE; average accuracy on neutral trials minus accuracy on positive trials) and a negative face effect (NFE; average accuracy on neutral trials minus negative trial accuracy). Larger scores on each of these indexes reflect greater impacts of emotional faces on response accuracy.

Executive control

Again following the literature, individual differences in overall executive control were operationalized as the extent to which working memory load reduced accuracy on the ENBACK task. To operationalize this load effect, a single executive control manifest variable ($M = 6.95\%$, SD = 9.20%) was calculated for each participant by subtracting accuracy on high load trials ($M = 79.23\%$, SD = 8.53%) from accuracy on low load trials ($M = 86.18\%$, SD = 9.35%).

Trying substances

This was the primary outcome measure, and it was assessed using a computerized version of the Timeline Follow Back questionnaire (Sobell & Sobell, 1992). On each of three items, youth received a "1" if they had tried any form of

alcohol, tobacco, or marijuana (e.g., "…have you EVER TRIED … at any time in your life… [a sip of alcohol such as beer, wine, or liquor (rum, vodka, gin, whiskey]"), and they received a "0" if they had not tried any form of alcohol.

Consumption of an entire alcoholic beverage or an entire cigarette (as opposed to a sip or a puff) was also assessed with two items: "How many STANDARD DRINKS of ALCOHOL such as beer, wine, or liquor (rum, vodka, gin, whiskey) have you had in your life?" and "How many TOBACCO PRODUCTS have you used in your life? (e.g., number of [entire] cigarettes)".

Base rates for these items were as follows: alcohol, $M = 23.4\%$, SD = 42.3%; tobacco, $M = 0.8\%$, SD = 8.7%; marijuana, $M = 0.12\%$, SD = 3.2%. For *significant* drug or alcohol consumption (as opposed to trying/experimentation), grand means revealed significant alcohol or tobacco consumption in some children (0.2% of children reported drinking an entire beer at any time in their lives; 0.2% of children reported consuming an entire cigarette). These variables are included for descriptive purposes only and are not incorporated into formal analyses.

Control variables

Control variables included sex, age, race, and parental socio-economic status (SES). Sex was encoded using a "biological sex at birth" item. The race variable collapsed races into five categories: White, African American, Asian, multiple race (indicating more than one race) and "other" (including all other racial identifications). SES was calculated by standardizing and averaging each parent's self-reported educational attainment (highest grade completed) and self-reported total household income.

Data analysis plan

An SEM was performed in R using the *lavaan (v.0.6)* package (Rosseel, 2012). The model (see Figure 1) included two latent factors consisting of (i) two self-report items measuring explosive irritability and (ii) two key ENBACK outcomes reflecting both positive and negative face effect difference scores. These two latent factors were entered as predictors of three separate variables measuring the extent to which individuals tried alcohol, marijuana, and tobacco. These substance trying items were therefore the dependent variables in the SEM. To control for socio-demographic characteristics of the child and rearing environment, the model included parental socioeconomic status (SES), age, sex, and race as covariates. A manifest variable for executive control was also included as a covariate. Parameters were estimated *via* maximum likelihood (ML).

Model fit was estimated with the following goodness of fit criteria: Comparative Fit Index (CFI; Bentler, 1990), Tucker-Lewis Index (TLI; Tucker & Lewis, 1973), root mean square of error approximation (RMSEA; Browne & Cudeck, 1992; Steiger, 1990), and standardized root mean square residual (SRMR; Maydeu-Olivares & Shi, 2017). Note that the chi-square fit was not assessed due to the biasing effect of large sample sizes on this metric.

See Table 1 for descriptive characteristics of key variables. Note: Because only 0.12% of children reported having tried marijuana, this segment of the model is extremely underpowered and therefore the marijuana results should be interpreted with extreme caution. The marijuana variable was retained in the analyses given that it was a key part of the a-priori data analyses plan.

Results

The SEM described above (see Figure 1) showed good fit (CFI = .994, TLI = .995, RMSEA = .011, SRMR = .071). All variables significantly and positively loaded onto their respective latent factors ($p < .001$). Explosive emotionality significantly positively predicted trying alcohol (β = .058, SE = .018, $Z = 3.279$, $p = .001$), trying marijuana (β = 1.049, SE = .194, $Z = 5.805$, $p < .001$), and trying tobacco (β = .104, SE

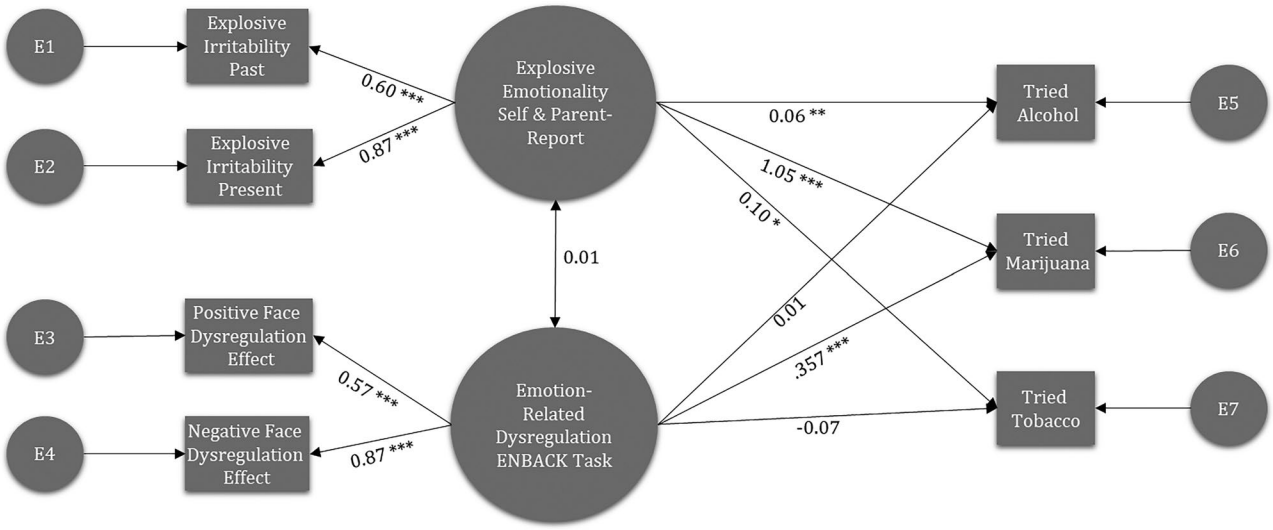

Figure 1. SEM results.
Note: *$p < .05$, **$p < .01$, ***$p < .001$

Table 1. Descriptive characteristics of key variables. Note: Other sample characteristics: $N = 7{,}418$; mean age = 9.9; sex = 47.9% female; race = 63.3% white, 15.7% African American, 7.2% Asian, 12.4% multiple race, and 1.3% other race.

Variable	Mean (SD)
Explosive Irritability Past	5.90 (23.56)
Explosive Irritability Present	1.11 (10.49)
Positive Face Dysregulation Effect	0.26 (8.49)%
Negative Face Dysregulation Effect	1.10 (8.57) %
Tried Alcohol	23.4 (42.3)%
Tried Marijuana	0.12 (3.2) %
Tried Tobacco	0.8 (8.7) %

= .045, $Z = 2.307$, p = .021). Emotion dysregulation as measured by the ENBACK-based latent variable was a significant predictor of trying marijuana (β = .357, SE = .057, $Z = 6.710$, $p < .001$). Age was only found to be significant for trying alcohol with a positive effect (β = .054, SE = .002, $Z = 3.444$, p = .001). Sex was found to significantly positively predict both trying tobacco (β = .175, SE = .118, $Z = 3.04$, p = .002) and trying alcohol (β = .062, SE = .032, $Z = 3.886$, $p < .001$). Parental SES was found to significantly positively predict trying alcohol (β = .175, SE = .020, $Z = 10.729$, $p < .001$), but significantly negatively predict trying tobacco (β = −0.131, SE = .077, Z = −2.112, p = .035). No demographic covariates were found to be significant for trying marijuana. Executive control was not found to be a statistically significant predictor of any substance trying variables.

Discussion

The present study examined cross-sectional data from the ABCD study to investigate links between dysregulated emotion and a tendency to try different substances in childhood. The results suggest that children exhibiting emotional reactivity were linked to more frequently trying substances in the form of sips of alcohol and puffs of tobacco. In addition, these findings were consistent across SES, gender, and age. We also show that the present effects are also consistent across executive control levels (as operationalized *via* general n-back task performance).

Theoretical implications

In interpreting these fascinating results, it is useful to first consider the low rates of significant drug or alcohol consumption observed in the present sample. Perhaps counterintuitively, these low rates may allow for a clearer interpretation of the current links between indicators of dysregulated negative emotion and trying substances. Although we have discussed research and theory suggesting a causal link between increased negative affect and increased substance consumption, there are also significant empirical and theoretical rationale suggesting the opposite direction of effect—that is, an effect of substance consumption on future experiences of emotional dysregulation and negative affectivity (Boschaloo et al., 2012; Chermack & Giancola, 1997; Marmorstein et al., 2010; Rohde et al., 2001). The theoretical explanation for this direction of effect is based on the impact of substance *abuse* on the emergence of stressors such as social or interpersonal difficulties, and these difficulties in turn are thought to increase experiences of sadness or other negative emotions (Swendsen & Merikangas, 2000). Similarly, substance abuse may cause increased negative emotion more directly, as evidenced by links between substance abuse and subsequent anger outbursts or behavioral indicators of anger such as violence (Chermack & Giancola, 1997).

However, the low prevalence of meaningful substance abuse in the current data (the proportion of children who reported drinking an entire beer in their lives was .2%) suggests that the presently observed link between dysregulated emotion and trying substances is unlikely to be explained by these theories linking substance consumption to negative emotion through the destructive impacts of heavy substance consumption. Thus, the presently observed link between indicators of excessive negative emotion and trying substances are more consistent with the "self-medication" theory's notion of dysregulated negative affect leading to consumptive behavior. This interpretation seems plausible given the previously discussed research associating early life substance use and a desire to relieve negative affect (e.g., Miller et al., 2017; Wills, Sandy, & Yaeger, 2001). From this perspective, given the array of existing theories relevant to the present results, perhaps the most plausible explanation for our findings is that dysregulated negative emotion (or a process indexed by dysregulated emotion) in children may increase the likelihood that children try substances.

Importantly, both dysregulated emotion and risky or deviant behavior (such as trying substances in childhood) tend to co-occur with deficits in self-regulation (for reviews, see Clark & Winters, 2002 and Tarter et al., 1999). Thus, one could posit that deficits in executive control could underlie both the emotional and conduct-related dysregulation observed in the present study. However, such an explanation seems less likely in the present data given that we assess and control for individual differences in working memory, which are thought to be a key indicator of executive control and self-regulation (Hofmann et al., 2012; 2013; Schmeichel et al., 2008; Verdejo-Garcia et al., 2006). Such ideas can help rule out the potentially confounding effects of third variables and further support the present interpretations of the results.

Clinical and theoretical Implications

To our knowledge, this is the first study to demonstrate links between dysregulated emotion and consumption of/trying multiple substances as early as in childhood (M_{age} = 9.9 years). This finding is striking and carries several implications. First, given that trying substances early in life has been among the most significant predictors of substance abuse later in life (see, for instance, Grant & Dawson, 1997; Griffin & Botvin, 2010; Gustavson et al., 2017), the present results suggest that dysregulated emotion in childhood may be a meaningful risk factor for substance use or abuse in adolescence or young adulthood. Although we cannot establish temporal precedence for negative emotionality in preceding trying substances, knowledge of how these early life

substance abuse risk factors manifest early in life could potentiate early detection and treatment of these risk factors.

Addressing substance abuse risk factors early in life may be important given that (i) true drug dependence is not typically established early in life (e.g., teenage years) and (ii) early intervention could prevent substance use behaviors from occurring and thereby avoid escalation to heavy drug use (Stockings et al., 2016). Early detection and intervention may be especially important for substance use given that substance use disorders have been relatively difficult to treat (Mignon, 2014). Treating substance use risk factors preemptively in youth has key advantages. First, affective disorders such as depression and anxiety often co-occur with substance abuse disorders (e.g., Swendsen & Merikangas, 2000) and the presence of depression or anxiety can make treating substance use more difficult. For instance, substance users with a comorbid condition are more likely to relapse (Laudet et al., 2004) and fail to comply with treatment. However, these disorders do not generally onset until after childhood, making this developmental stage a potentially effective time to address substance abuse or substance abuse risk factors before the emergence of complicating effects of affective disorders. Secondly, and perhaps even more importantly, dysregulated emotion is also thought to be a core driver of depressive and anxiety disorders (Aldao, 2012; Barlow et al., 2013; 2017; Sloan et al., 2017). From this perspective, targeting children who display difficulties with emotional dysregulation with evidence-based substance abuse mitigation strategies could simultaneously reduce the risk of trying substances, as well as early life onset of depressive or anxiety disorders. Such intervention strategies have included prevention programs that are teacher-administered (Lize et al., 2017), parenting-based (Allen et al.,2016), and peer-based (MacArthur et al., 2016).

Similarly, given that our findings are (i) inconsistent with theoretical accounts of substance use driving dysregulated negative emotion, and (ii) aligned with theories suggesting an effect of excessive negative emotion leading to substance use (e.g., Turner et al., 2018), the present results would seem to also provide additional support for transdiagnostic perspectives on negative emotionality (Barlow et al., 2013) and emotion dysregulation (Sloan et al., 2017). Such frameworks implicate excessive negative emotionality as the central driver of an array of psychological disorders, including substance abuse disorders (Aldao, 2012; Barlow et al., 2013; 2017; Sloan et al., 2017). If these theories continue to receive empirical support, they have the power to transform the way psychopathology is conceptualized, treated, and even prevented (Barlow et al., 2017).

The current analyses revealed limited evidence for the expected link between trying substances and dysregulated emotion systems as indexed by the ENBACK. Given that the ENBACK latent variable did not covary with the explosive emotion reactivity latent variable (see Figure 1), it may be that ENBACK performance is less directly related to emotion reactivity as presently operationalized. One plausible reason for this discrepancy between ENBACK and self-reported emotionality findings could relate to challenges that cognitive assessments have in achieving ecological validity. Although the ENBACK has shown some convergent validity as a measure of dysregulated emotion (Bertocci et al., 2012; Ladouceur et al., 2009), laboratory-based tasks like the ENBACK, naturally, operationalize emotional dysregulation in a less direct way than self-reports.

Limitations

The present data structure is a cross-sectional one. Consequently, our data does not allow for direct insight into the temporal relationship between individual differences in dysregulated emotion and trying substances. Although the effect sizes associated with the impact of dysregulated emotion on the substance trying outcomes (see Figure 1) are somewhat small, such effect sizes are quite common in social science, and often have characterized seminal and replicable effects (Funder & Ozer, 2019).

The present conclusions related to the ENBACK task are somewhat limited in that (i) they rely on a single emotion-reactivity task measured at a single point in time and (ii) are based on data which did not include roughly 15% of the participants, mostly due to high error rates (error rates of 40% or greater). Furthermore, although children's tendency to externalize intense emotional experiences like anger, frustration, or aggression is thought to be strongly related to dysregulated emotion in general (Giesbrecht et al., 2010; Nock et al., 2008), the current results may not fully generalize to other operationalizations of dysregulated emotion in children. Other than socioeconomic status, the present investigation did not control for factors of the home environment that have been linked with substance trying (e.g., parental monitoring). For this reason, we cannot rule out the possibility that our substance trying outcomes partially reflect such factors.

Finally, this investigation relied on self-reported measures of substance use. Although these measures were designed to minimize bias, and children's responses to substance use questions were kept fully confidential, these responses still faced limitations related to social desirability bias, memory recall bias, and potential difficulty understanding or answering questions about substance use. These forms of bias could cause the true prevalence of risky behaviors like trying various substances in the present sample to be much higher than was reported here (Cheung et al., 2017).

Conclusions

The present results are novel in that they show links between several indicators of dysregulated negative emotion and a tendency to try illicit substances at surprisingly early ages. Additionally, the present analyses control for individual differences in working memory, a key indicator of executive control and related self-regulation. This statistical control would seem to decrease the likelihood that deficiencies in self-regulation could explain both dysregulated emotions and trying substances in the present data. In addition, by demonstrating links between that emotional dysregulation and trying substances can emerge normatively as early as age nine,

the present findings provide additional motivation for early detection and interventions targeting trying substances among children displaying dysregulated emotion. We suggest that future research should examine the long-term impacts of emotion-regulation interventions administered in childhood—specifically, the impacts of such interventions on substance use later in life.

Ethical considerations

Ethics approval was sought from the Adolescent Brain Cognitive Development (ABCD) study. Ethics approval was obtained from all relevant institutional research ethics boards as well as signed informed consent from parents/guardians and assent from participating children.

Disclosure statement

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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