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Developmental trajectory classes in psychological dysregulation predict later decision-making competence

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HIGHLIGHTS

- Psychological dysregulation was prospectively associated lower decision competence.
- Distinct classes for developmental trajectories of psychological dysregulation.
- Low decision competence was associated with a problematic dysregulation trajectory.

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ABSTRACT

Adolescence and emerging adulthood are developmental periods associated with increased risk taking, including alcohol and substance use and antisocial behaviors. Typical psychological growth from adolescence into early adulthood reflects increases in traits related to psychological regulation (e.g., greater emotional stability and less impulsivity), which are typically considered protective factors against risk behaviors. However, individuals may vary greatly in their development of these characteristics. This study examines the degree to which heterogeneity in developmental trajectories of psychological regulation are associated with later performance on decision-making skills battery. In this study, psychological regulation was assessed at age 10–12, with follow-up assessments at 14, 16, and 19 years. At age 19, we administered the Youth Decision-Making Competence (DMC; Parker & Fischhoff, 2005) measure. Correlational analyses revealed that lower psychological regulation, as early as age 10, was associated with lower DMC scores. A latent class growth mixture model yielded three distinct developmental trajectory classes of psychological dysregulation: (a) a Moderate-Stable group, a modal class that demonstrated stable and average regulative tendencies throughout adolescence, (b) a Low-Decreasing group, which demonstrated greater self-regulation throughout childhood, and a (c) High-Increasing group, which demonstrated low self-regulative tendencies (higher dysregulation) at age 10 that became increasingly dysregulated throughout adolescence. Individuals in the High-Increasing group demonstrated lower DMC performance than those in the Moderate-Stable and Low-Decreasing groups. Our findings also reinforce past work that indicates considerable individual differences in intra-individual change across adolescence, and that early patterns of psychological dysregulation development can impact later decision-making tendencies.

1. Introduction

The transition from adolescence to emerging adulthood is a developmental period associated with increased risk taking, including increases in alcohol and substance use and antisocial behaviors (Arnett, 1992). In the United States, the rates of ever using any illicit drug ranged from 18.7% among 8th graders to 47.8% among 12th graders, and, and alcohol use ranged from 23.5% to 58.5% (Johnston et al., 2019). Poor decision-making skills, a common characteristic in those with externalizing disorders, such as Substance Use Disorder (SUD; Noël et al., 2013), is often also observed in this age cohort – which may lead to a greater likelihood of engaging in health-risking behaviors (Romer et al., 2017). Thus, understanding the factors that may contribute to the presence of suboptimal decision-making has the potential to provide valuable insights into the development of SUD.

For children of parents with a SUD, the likelihood for engaging in problematic risk behaviors are even greater (Vanyukov et al., 2003). Research suggests that a cluster of dispositional tendencies may precede initiation of problematic substance use, including irritability, attentional,

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and behavioral problems (Clark et al., 2005; Tapert et al., 2005). Clark and Winters (2002) referred to this constellation of characteristics as *psychological dysregulation,* which encapsulates behavioral, cognitive, and emotional regulatory tendencies. These characteristics may be viewed as indicators of intergenerational (i.e., transmissible) risk, representing the combined impact of heritability with the influences of parenting practices and other psychosocial interactions, in turn contributing to one's *liability*, or the probability, to develop a disorder (Falconer, 1965).

Vanyukov et al. (2009) developed an item-response theory-derived unidimensional scale termed the *transmissible liability index (TLI),* which aims to identify the most salient characteristics common to intergenerational SUD risk between parents and children. TLI indicators reflect individual differences across a range of self-regulative tendencies, both in terms of behavioral undercontrol, as well as attentional and affective dysregulation. Notably, TLI can be contrasted with other externalizing disorder scales by the inclusion of items related to emotional instability and internalizing symptoms that may exacerbate risk for the development of SUD. TLI scores during childhood have been shown to identify college students who later develop SUD (Arria et al., 2009). Additionally, Kirisci et al. (2009) found that higher TLI is a significant predictor of cannabis use disorder in young adulthood (Vanyukov et al., 2009). Further, boys with lower TLI scores at age 10–12 had scores decrease over time (i.e., greater psychological regulation), whereas high scorers showed increases through adolescence (i.e., greater dysregulation), and this slope became steeper after initiation to cannabis use (Kirisci et al., 2013).

Though research demonstrates the predictive accuracy of TLI for later SUD risk, less is known about the degree to which TLI is related to decision processes that may be associated with maladaptive behaviors. One approach to assessing decision quality is to compare individuals' choices to the optimal choice based on theories of normative rationality, such as Expected Utility Theory (Von Neumann and Morgenstern, 1947). Although normative responding may not always lead to an intended outcome, consistently making choices in this manner will lead to more favorable long-term outcomes (Hastie & Dawes, 2010; Stanovich et al., 2016). Some researchers have referred to objective performance on these tasks as decision-making competence (DMC; Parker and Fischhoff, 2005). DMC performance is based on two criteria for rationality: making objectively accurate judgments or choices, and being consistent in judgments/choices across objectively equivalent decisions presented in contextually different manners.

Individual differences in DMC performance have been associated with general cognitive ability and executive function across the lifespan (Bruine de Bruin et al., 2007; Del Missier et al., 2012; Parker et al., 2018). In a pre-adolescent sample, Weller et al. (2012) found that DMC scores were associated with dispositional inhibitory control, and lower DMC scores predicted reported interpersonal difficulties (e.g., peer and conduct problems) two years later (Weller et al., 2014). Additionally, DMC scores are associated with retrospective and concurrent reports of substance use and health-risking sexual behavior (Bruine de Bruin et al., 2007; Parker et al., 2018; Weller et al., 2015a).

Though this research suggests that lower DMC performance is associated with psychological dysregulation, the relationship between developmental trajectories of self-regulation and later instantiations of normative decision-making tendencies have not been examined. Consequently, research is also silent regarding potential heterogeneity in these trajectories, which may differentially predict decision-making skills. To address these issues, we adopt a person-centered approach to account for the proposed heterogeneity in psychological regulation, measured as transmissible SUD risk, trajectories across youth and adolescence (ages 10–12, 14, 16, & 19; Kirisci et al., 2007). Then, we test the degree to which latent trajectory classes account for variance in DMC scores at age 19.

2. Methods

2.1. Participants

The original dataset consisted of 775 children and their families, who were recruited into a longitudinal study of the etiology of substance abuse in adolescence (Tarter and Vanyukov, 2001). Families were selected based on the SUD status of the biological father of a 10–12 year old child. Fathers were either (1) SUD+, defined as current or past DSM-III-R diagnosis of SUD consequent to illicit use of substances other than alcohol, or (2) SUD-, those fathers who had no current or past SUD or any other psychiatric diagnosis. Families were excluded if the father had a neurological disorder, schizophrenia, or uncorrectable sensory incapacity or if the child had a neurological injury which required hospitalization, IQ $<$ 80, chronic physical disability, uncorrectable sensory incapacity, or psychosis. Both parents and 10–12 year old child were enrolled into the project, and the child was re-assessed at ages 12–14 (2 years post-enrollment; N = 582), 16 (N = 546), and 19 (N = 458). Attrition in this study was not progressive; that is, participants who missed an assessment could participate in subsequent waves. We report attrition-related analyses in an online supplement. Analyses included participants who completed the Youth DMC (Y-DMC) assessment and had at least one TLI score, leaving a total sample size of N = 456 for these analyses (149 female; 72.1% Caucasian, 25.2% African-American, 2.6% reported bi-racial ethnicity). 29.8% of the participants' families achieved a high school degree (or equivalent) or less, 33.8% had a parent who completed some college, a technical college, or trade school, 21.5% with a 4-year university degree, and 14.9% with schooling beyond the bachelor's degree level. Participants were compensated for their time at the end of each assessment at a rate comparable to the U.S. minimum wage. The study was approved by the Institutional Review Board at the University of Pittsburgh.

2.2. Measures

2.2.1. Transmissible liability index (TLI)

TLI items measure wide range of characteristics which are indicative of overall biopsychological self-regulation. The rationale and method of deriving the TLI have been described in prior reports (Vanyukov et al., 2009; Kirisci et al., 2009). The TLI was derived from items contained in 24 psychological and psychiatric instruments administered to parents, teachers, and offspring (Center for Education and Drug Abuse Research, 2019)[1]. Besides externalizing behaviors, the TLI includes items pertaining to thoughts about death during stress, self-harm, biting fingernails, poor sleep, irregular appetite, somatic distress, and adapting to new situations. The TLI has been validated at each assessment point: The TLI has 45 items at age 10–12, 51 items at age 12–14, 64 items at age 16, and 65 items at age 19, with IRT-based reliability coefficients of 0.93, 0.91, 0.95, and 0.93, respectively. Using IRT-based horizontal equating methodology, TLI scores were equated to control for age-related differences in item salience. Higher TLI scores reflect more psychological dysregulation (e.g., greater impulsivity, lower emotional stability).

2.2.2. Decision-Making competence

At the age 19 assessment, participants completed Parker and Fischhoff's (2005) Youth Decision-Making Competence (Y-DMC) measure, designed for adolescent and emerging adult populations. The Y-DMC score is an unweighted average of performance on six tasks, selected to cover skills implicated in normative theories of decision making, including: (a) *Resistance to Framing*, which measures the extent to which choices are unaffected by formally irrelevant variations in how options are described (e.g., condom effectiveness described in terms of success or failure rates); (b) *Resistance to Sunk Costs*, which measures the willingness to abandon irrecoverable prior investments, considering only future consequences; (c) *Consistency in Risk Perception*, which measures internal consistency of sets of risk judgments (e.g., the judged chance of dying from any cause "in the next year" should be no larger

[1] Full descriptions of visit-specific TLI items can be found at http://www.pitt.edu/~cedar/TLIdocument.html. See online supplement for additional information about TLI development.

Table 1
Intercorrelations between Study Variables.

	1	2	3	4	5	6	7	8
1. TLI Visit 1 (10–12 years)	–							
2. TLI Visit 2 (14 years)	0.51	–						
3. TLI Visit 3 (16 years)	0.40	0.58	–					
4. TLI Visit 4 (19 years)	0.42	0.56	0.71	–				
5. Parental SUD + (0 = no; 1 = yes)	0.15	0.21	0.27	0.30	–			
6. Neighborhood Disadvantage	0.11	0.23	0.18	0.16	0.15	–		
7. Sex (0 = males; 1 = female)	−0.25	−0.17	−0.13	−0.15	−0.02	−0.02	–	
8. YDMC	−0.14	−0.25	−0.27	−0.29	−0.21	−0.40	−0.07	–

Note. N ranges from 349 to 456. Correlations above |0.12| are significant at $p < .01$. TLI = Transmissible Liability Index; SUD+ = Parental Substance Use Disorder positive status; YDMC = Youth-Decision Making Competence.

than the same risk judged "between now and when you turn 30"); (d) *Applying Decision Rules*, which measures the ability to accurately apply specific decision rules within hypothetical choices; (e) *Under/over-confidence,* which measures the discrepancy between percent correct on a true/false knowledge questionnaire with the mean respondent's perceived confidence for correctly answering each choice (50% = just guessing; 100% = absolutely sure); and (f) *Recognizing Social Norms*, which measures the calibration between a respondent's estimation of the degree to which an undesirable behavior is normative (e.g. "out of 100 people your age, how many would say it is sometimes 'OK' to steal under certain circumstances") and the actual percent of study respondents who endorsed that "it is sometimes 'OK' to engage in each behavior." Higher Y-DMC scores indicate greater consistency and resistance to bias (i.e., higher competence).

2.2.3. Covariates

2.2.3.1. Participant sex. Because of notable sex differences in both self-regulatory traits and certain DMC components (Chapple and Johnson, 2007; Weller et al., 2018), we included participant sex as a covariate in our analyses.

2.2.3.2. Parental SUD. An expanded version of the Structured Clinical Interview for DSM-III-R (SCID) was administered to both parents to characterize lifetime and current substance use disorders. The DSM-III-R taxonomy was employed because this research was initiated prior to publication of the current DSM-V manual. Diagnoses were formulated during a clinical conference chaired by a psychiatrist certified in addiction psychiatry and attended by another psychiatrist or a psychologist, along with the clinical associates who conducted the interviews. The best estimate procedure was used to formulate the diagnoses (Leckman et al., 1982). Parental SUD + status was defined as the presence of at least one parent who met DSM-III-R criteria.

2.2.3.3. Neighborhood disadvantage. To account for global environmental factors, we included a measure of neighborhood disadvantage (Ross & Mirowsky, 2001). The addresses of enrolled families were geocoded and matched to census tracts for either the 1990 or the 2000 U.S. Census, based on year of recruitment into the project. Census data from each tract representing the (1) rate of households living below the poverty level (POV), (2) the percentage of families with children with mother only as head of household (MHH), (3) the rate of owner-occupied housing units (OOH), and (4) the rate of adults over age 24 with college degrees (COL) living within the census tract were matched to family addresses. The neighborhood disadvantage variable was represented as $[(POV * 0.1) + (MHH * 0.1)] - [(OOH * 0.1) + (COL * 0.1)]/4$. The higher the value, the greater the degree of neighborhood disadvantage.

2.2.3.4. Data analytic plan. We fit a Latent Class Growth Model (LCGMM; Jung and Wickrama, 2008; Muthén, 2001), which simultaneously determines (a) the number of distinct latent trajectory classes and assigns individuals to each class, (b) the association between latent class and covariates using a multinomial logistic regression, and (c) the association between classes and outcomes. Covariates were included in these models, with direct paths to class membership and latent growth factors. Based on the observed correlations, we also included direct paths between Y-DMC scores and both neighborhood disadvantage and parental SUD + status. Selection of the best-fitting model was based on AIC and BIC fit statistics, Lo-Mendell-Rubin Likelihood and bootstrapped Likelihood-Ratio tests of competing models (starting from a single class model), interpretability of trajectory classes based on theoretical considerations, and the number of respondents assigned to the smallest class (Rindskopf, 2003). We tested the adequacy of latent class models until the fit indices suggested that the addition of another class would not improve model fit. LCGMM were run with 1000 sets of random start values. Inspection of the −2loglikelihood values (−2LL) suggested that a local maximum was not met.

3. Results

Table 1 shows the correlations among TLI scores, demonstrating moderate to strong stability across the four visits. Even for the maximally distal assessments, we observed moderate stability in TLI scores ($r = 0.42$). As the child grew older, correlations strengthened, especially between the age 16 and 19 assessments ($r = 0.71$). Substantial variance remains unaccounted for, suggesting that this trait may be malleable throughout development.

Across visits, participants with an SUD+ parent reported higher TLI scores. Moreover, greater neighborhood disadvantage was associated with higher TLI scores. Additionally, males had higher TLI scores than females across all visits. In contrast, higher Y-DMC scores were associated with lower TLI scores, greater levels of neighborhood disadvantage and a higher likelihood of Parental SUD+, but were not significantly associated with sex.

3.1. Latent class growth mixture model (LCGMM) analyses

Model fit statistics for the LCGMM analyses suggested three- and four-class solutions were both plausible (Table 2). We rejected the 4-class model due to higher BIC values compared to the 3-class model, and a non-significant LMR-LRT value. For the 3-class model (Fig. 1), the first class, labeled *Moderate-Stable,* showed average initial TLI scores which remained stable throughout the four visits, which had the highest membership rate (49.6%). The second class, *Low-Decreasing,* could be defined as having the lowest initial TLI scores (i.e., lowest risk), which progressively became lower over time (24.3%). Finally, the *High-Increasing* class began the period with greater TLI, which increased over time (26.0%).

Only participant's sex was significantly associated with the latent growth intercept factor, indicating that boys had higher initial TLI scores than girls (See Fig. 2). Next, latent class membership was regressed on sex, neighborhood disadvantage, and parental SUD + status (see Table 3). In contrast to the Moderate-Stable class, individuals in the High-Increasing class were more likely to live in a neighborhood with greater disadvantage, and also were more likely to have a parental SUD + diagnoses present in the family. Conversely, compared to the

Table 2
Fit Indices for Competing Models.

Model	Log Like-lihood	# Para-meters	AIC	BIC	Adj. Lo-Mendel-Rubin LRT	Adj. LMR p-value	Boot-strapped p-value	Average Pred. Prob. LC Membership
1-class	−2542.61	11	5107.23	5152.36				
2-class	−2320.01	18	4676.02	4749.86	445.21	< 0.001	< 0.001	93.1%
3-class	−2253.10	25	4556.20	4658.76	130.76	< 0.001	< 0.001	88.7%
4-class	−2234.60	31	4533.20	4664.48	36.15	0.21	< 0.001	84.3%

Note. Entropy = 0.76 for the 3-class model.

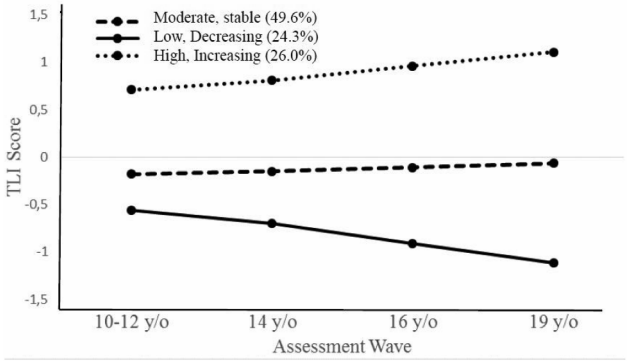

Fig. 1. Developmental Trajectories in TLI by Latent Class Membership.

Moderate-Stable group, Low-Decreasing class membership was associated with a lower likelihood of parental SUD + diagnosis, and included more females than males. Finally, compared to the Low-Decreasing class, individuals in the High-Increasing class were more likely to be male, live in a disadvantaged neighborhood, and have a parent with a SUD + diagnosis.

Finally, we assessed the degree to which trajectory class membership accounted for Y-DMC scores at age 19, controlling for significant covariates (see Fig. 3). Of the covariates, only Neighborhood Disadvantage was directly, negatively associated with DMC scores. A Wald test of parameter constraints to test for the equality of means across class found significant differences in YDMC scores between classes, Wald (2) = 38.19, $p < .001$. Fig. 3 plots Y-DMC scores for the three classes. As predicted, the most dysregulated class (High-Increasing) demonstrated the lowest Y-DMC scores, both compared to the Low-Decreasing class, Wald (1) = 37.05, $p < .001$, and the Moderate Stable class, Wald (1) = 22.18, $p < .01$. The Wald test for simple effects between the Moderate-Stable and Low-Decreasing classes was marginally different with respect to Y-DMC performance, Wald (1) = 3.15, $p = .07$.

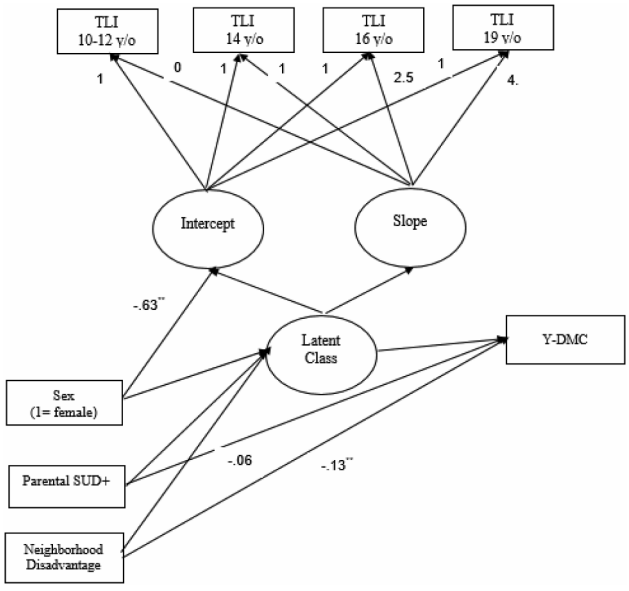

Fig. 2. Latent Class Growth Mixture Model Analysis.

4. Discussion

Though past research has clearly shown the link between substance use and TLI (Hicks et al., 2004; Kirisci et al., 2015; Ridenour et al., 2011; Vanyukov et al., 2009), this study is the first to demonstrate that TLI is linked to potential social-cognitive mechanisms that may relate to health-risking behaviors. This study reinforces and extends current knowledge in several ways. First, we found that children's developmental trajectories for TLI over the course of a 9-year period were heterogeneous, but could be classified by three latent classes reflecting distinct developmental patterns. Second, consistent with past research (Tarter et al., 2009; Tarter et al, 2013; Ridenour et al, 2009), parental SUD + status, sex (male), and neighborhood disadvantage were associated with a greater likelihood of a child having a TLI developmental trajectory characterized by greater dysregulation which progressively worsened over time. Third, we demonstrated that a dysregulated TLI trajectory was associated with lower decision-making competence scores.

Germane to the TLI construct, researchers interested in personality development have proposed the "maturity principle," by which individuals become more emotionally stable and self-regulated from childhood into adulthood (Roberts and Wood, 2006). In general, adolescence is often characterized as an age period associated with increased antisocial behaviours and risk taking, which is often considered to be a part of typical development (e,g., Moffitt, 2006). However, it is believed that a small subpopulation of adolescents maintains a persistent level of impulsivity, leading to elevated rates of problematic behaviours (Bjork and Pardini, 2015). Our study highlights the heterogeneity in developmental patterns (Donnellan et al., 2007), and identifies a cluster of individuals who become more self-regulated over-time, as well as a group of adolescents who display persistent, and elevated, psychological dysregulative tendencies. This latter group appears not only to be related to parental and environmental risk factors, but also is associated with suboptimal decision-making skills later in life.

Research suggests that poor decision making may be a hallmark characteristic of SUD. Early studies using laboratory-based decision-making tasks have demonstrated that substance abusers perform poorly compared to healthy controls (Bechara et al., 1999, 2001; Grant et al., 2000; Mazas et al., 2000). Suboptimal decision making also has been observed in other externalizing disorders, such as ADHD (Mäntylä et al., 2012; Toplak et al., 2005), Conduct Disorder (Crowley et al., 2006; Kim et al., 2006), and pathological gambling (Brevers et al., 2013; Buchanan et al., 2019). The current research demonstrates that SUD liability is associated with poor decision-making skills that extend beyond risk taking and delay discounting performance (Kirby et al., 1999; Bechara et al., 2001). These findings are important because development of specific decision-skills may have different antecedents and be subserved by distinct underlying mechanisms (Stanovich et al., 2016).

These results also extend the DMC literature by not only identifying a dispositional predictor, but also how its development may impact decision performance. Prior research investigating self-regulatory constructs as antecedent predictors of DMC have been relatively sparse, and have

Table 3
Parameter Estimates for final LCGMM Model.

	Latent Class					
	High-Increasing		Moderate, Stable		Low-Decreasing	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	0.76**	0.09	−0.15*	0.06	−0.67**	0.08
Slope	0.10**	0.03	0.03	0.02	−0.14**	0.02
Predictors of Latent Class Membership-Group Comparisons						
	High vs. Moderate		High vs. Low		Low vs. Moderate	
	B	SE	*B*	SE	*B*	SE
Sex	0.26	0.33	1.67*	0.66	−1.34*	0.54
Parental SUD +	1.06**	0.31	1.75**	0.36	−0.66*	0.30
Neighborhood disadvantage	0.37**	0.11	0.46**	0.16	−0.10	0.17

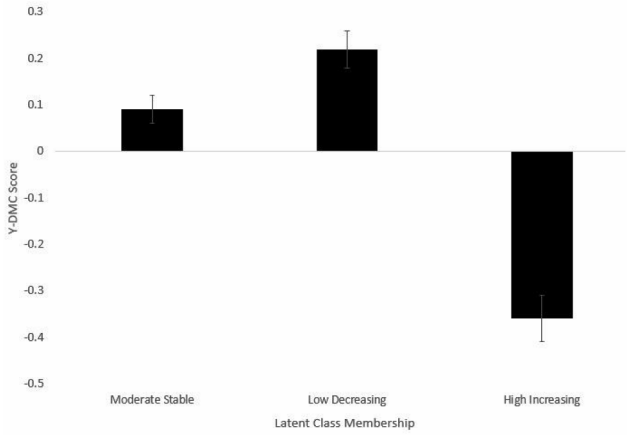

Fig. 3. Y-DMC Scores by Latent Class Membership.

been limited to concurrent correlational analyses (Del Missier et al., 2012; Mäntylä et al., 2012; Parker et al., 2018; Weller et al., 2018). In contrast, the current study suggests that *how* an individual's developmental trajectory progresses also matters when accounting for variance in DMC.

The current findings may eventually inform future prevention efforts. Past research has demonstrated that TLI scores predict SUD and covary with the time of substance use onset (Arria et al., 2009; Ridenour et al., 2011; R. Tarter et al., 2013; R.E. Tarter et al., 2015; Kirisci et al., 2013; Reynolds et al., 2011). The current study extends this knowledge by suggesting that the liability phenotype predicts later instances of suboptimal decision-making skills. Decision skills training potentially could be an important addition to intervention efforts, especially for youths most vulnerable for developing SUD and initiating other health-risking and antisocial behaviors. Training of decision skills could be a valuable supplement to other evidence-based programs that stress more general skills such as goal-setting and emotional regulation (Edalati & Conrod, 2019; Weller et al., 2015b).

4.1. Limitations

Although we are enthused by these results, we must acknowledge several limitations. Foremost, the current study cannot address DMC's developmental trajectory, and how it may parallel the developmental patterns of self-regulatory tendencies. Because it is believed that different decision skills may have distinct trajectories across the lifespan, and may be mediated by varying processes, we feel that it should be a priority to conduct longitudinal decision-making research (Romer et al., 2017). Second, selective attrition may have skewed the results. However, though we cannot fully rule out its effects, missed assessments were not meaningfully associated with either differential TLI or Y-DMC scores, consistent with prior research (Horner et al., 2015). Additionally, inclusion criteria for participants in the CEDAR sample who had parental SUD + diagnoses did not include Alcohol Use Disorder. Thus, we caution generalizations across these disorders.

Finally, we must underscore that both human development and addiction are both highly complex processes. Thus, our results only illuminate one perspective. Factors such as, but not limited to, culture, early initiation of illicit substances (i.e., alcohol, smoking) identity, parenting practices, peer relationships, social roles, and social media use may all relate to the development of SUD and self-regulation (Klimstra & Denissen, 2017; Sawyer et al., 2012; Staff et al., 2010; Stone et al., 2012). Further, some research has suggested that self-regulation may both facilitate and restrain addictive behavior (Baumeister and Vonasch, 2015), suggesting multiple consequences for these tendencies. Future research would benefit from studies that address these issues with greater precision.

4.2. Conclusion

To our knowledge, this study represents the first effort to characterize the degree to which the development of psychological regulation is associated with later instantiations of suboptimal decision-making tendencies. We feel that the results have implications both for identifying adolescents at-risk for poor decision making and for the design of interventions to prevent SUD. We hope that future research may further elucidate how environmental variables shape trait development, and in turn, the ways individuals make health-effacing choices.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.addbeh.2020.106650.

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