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Developmental joint trajectories of anxiety-depressive trait and trait-aggression: implications for co-occurrence of internalizing and externalizing problems

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Abstract

Background. In youth, anxiety-depressive traits (ADT) and trait-aggression (TA) are important risk factors of exhibiting maladaptive behaviors in adulthood (i.e. violence and substance use). However, the developmental co-occurrence of these traits in youth remains unknown. We thus sought to investigate the developmental trajectories of ADT and TA within a data-driven approach. The aim was two-fold: (i) to examine the developmental trajectories of ADT and TA in youth from ages 10 to 16, and (ii) to investigate both childhood predictors and problematic outcomes of the identified joint trajectories.

Method. The sample comprised 1354 children provided from the Longitudinal Studies of Child Abuse and Neglect (LONGSCAN) Consortium. Group-based trajectory modeling was first employed to identify individual trajectory models of ADT and TA independently (from ages 10 to 16). Then, joint trajectory models were built on the found trajectories. Last, logistic regressions were used to evaluate the childhood characteristics and negative outcomes of the joint trajectory groups.

Results. Our results showed five trajectory groups with varying levels of ADT and TA. A significant co-occurrence between ADT and TA was found in three of the trajectory groups. Notably, higher levels of childhood psychopathology and more severe/frequent childhood abuse were found in the groups with moderate to high ADT and high TA. The groups with higher ADT and high TA were also more likely to exhibit violence and substance use.

Conclusions. This study exposes the importance of assessing ADT and TA simultaneously and early in childhood to prevent and manage the risk of problematic behaviors in adolescence.

Introduction

In the last few decades, there has been growing interest in the understanding of different trajectories to problematic behaviors (Achenbach *et al.*, 2016). In fact, research on developmental psychopathology has mainly focused on two different trajectories leading to risky behaviors (i.e. substance use, violence and suicidal behaviors): the internalizing and externalizing paths (Achenbach *et al.*, 2016). While internalizing and externalizing paths are defined by factor analyses as higher-order factors, they both comprise several different constructs (lower-order factors). In fact, internalizing problems generally comprise social withdrawal, somatic complaints and anxiety-depressive trait (ADT); externalizing problems comprise delinquent behaviors and trait-aggression (TA) (Achenbach, 1991). Thus, while some individuals with internalizing problems (i.e. social withdrawal, ADT) would be at risk of suicidal behaviors and substance use problems, others with externalizing problems (i.e. delinquency and TA) would also be at risk of these problematic behaviors (Achenbach *et al.*, 2016). Although these constructs are commonly studied separately, some have found that both seem to co-occur (Colder *et al.*, 2013), as illustrated by the moderate correlation between them ($r = 0.45–0.54$) (Achenbach *et al.*, 2016).

The co-occurrence of both trajectories is mainly detected in literature on conduct disorder (CD) and antisocial personality disorder (ASPD) (Wolff and Ollendick, 2006; Cunningham and Ollendick, 2010). In fact, some results suggest that approximately 30% of children with major depressive disorder also meet the criteria for CD and conversely, 50–76% of children with CD meet the criteria for a diagnosis of mood disorder (Arredondo and Butler, 1994; Greene *et al.*, 2002). Interestingly, in a recent review, Fanti (2018) found that this comorbid subgroup is characterized by over-arousal of the autonomic nervous system and severe emotional

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dysregulation. Despite some authors suggesting that ADT attenuates the severity and course of CD (Mason *et al.*, 2004), others have observed opposite results (e.g. additive effect) (Capaldi, 1992; Miller-Johnson *et al.*, 1998; Ezpeleta *et al.*, 2006; Ingoldsby *et al.*, 2006; Cunningham and Ollendick, 2010; Hodgins *et al.*, 2010). Thus, the relationship between these constructs remains unclear. Fergusson *et al.* (1996) have found that the shared variance between CD and affective disorders was mainly accounted by common risk factors (i.e. two-thirds). As observed in several psychopathologies and maladaptive behaviors, one promising explanation for such overlap is a shared underlying risk factor: negative affect dysregulation (Wolff and Ollendick, 2006; Hussong *et al.*, 2011; Wills *et al.*, 2016). There is therefore a need to better understand this overlap developmentally (Fergusson *et al.*, 1996; Wolff and Ollendick, 2006; Cunningham and Ollendick, 2010).

Developmental psychopathological research has focused on identifying the antecedents and consequences of negative emotion dysregulation. Several authors have found strong relationships between childhood abuse, social problems (e.g. victimization), attention deficit/hyperactivity disorder (ADHD) and an increased vulnerability to display negative affect problems in adolescence (Chronis-Tuscano *et al.*, 2010; De Pauw and Mervielde, 2010; Shaw *et al.*, 2014). First, substantial evidence from meta-analyses and literature reviews indicates that childhood abuse and neglect increased significantly the risk of developing (in general) negative emotion dysregulation (Dvir *et al.*, 2014; Infurna *et al.*, 2016). Although this seems to be particularly the case for anxiety/depressive mood dysregulation (Dvir *et al.*, 2014; Infurna *et al.*, 2016), childhood abuse also appears to impact significantly the course of anger dysregulation (Kolla *et al.*, 2013; Liu *et al.*, 2013; Gardner *et al.*, 2014; Iverson *et al.*, 2014; Ramirez *et al.*, 2015). Second, several findings suggest that impulsivity is a core feature of negative emotion psychopathologies (Links *et al.*, 1999; Sebastian *et al.*, 2013; Berg *et al.*, 2015). In fact, meta-analyses and literature reviews suggest a significant trajectory between ADHD and negative emotion psychopathologies (e.g. BPD, ASPD) (Sebastian *et al.*, 2013; Graziano and Garcia, 2016). Although the directionality between the two constructs is not well understood (Sebastian *et al.*, 2013), findings support that higher impulsivity increases the severity of negative emotion dysregulation (Factor *et al.*, 2014; Shaw *et al.*, 2014; Stepp *et al.*, 2016; Moukhtarian *et al.*, 2018).

Moreover, problems with regulating intense negative emotions in youth is known to increase the likelihood of suicidality (Zlotnick *et al.*, 1997; Weinberg and Klonsky, 2009), physical aggression (Beauchaine *et al.*, 2009; De Pauw and Mervielde, 2010) and substance use (i.e. alcohol, cannabis and cigarette) (Weinberg and Klonsky, 2009; Cheetham *et al.*, 2010) in young adulthood. Whereas externalizing symptoms are known to be consistently associated with substance use (Hussong *et al.*, 2011), the unique association between internalizing problems and substance use is less clear (Hussong *et al.*, 2011). Nevertheless, recent studies have shown that a subgroup of youth at risk for substance use problems is characterized by co-occurring internalizing-externalizing problems (Colder *et al.*, 2013). Moreover, the co-occurrence of TA and ADT in adolescence was found to be associated with more ASPD traits, lifetime alcohol and/or substance use disorders and lifetime suicide attempts in adult prisoners compared with TA without ADT (Hodgins *et al.*, 2010). A few studies on this subject highlight the necessity to better understand this co-occurrence in the development of psychopathologies and at-risk behaviors.

Yet, there are a limited number of longitudinal studies on internalizing-externalizing pathways associated with problematic behaviors. Moreover, very little attention has been paid to the within-subject variability between both constructs (Hussong *et al.*, 2011). Therefore, the heterogeneity of co-occurrent internalizing–externalizing traits linked to subsequent problematic behaviors remains unclear. A method to overcome this issue is joint trajectories analysis, which allows identifying developmental distinctive clusters based on within-person joint trajectories of two constructs (Nagin and Tremblay, 2005). For example, a recent study using this approach showed that children with high irritability and high depressive/anxious mood, and to a lesser extent moderate irritability and low depressive/anxious mood (at ages 6–12) were significantly more likely to report higher rates of suicidality at ages 13–17 (Orri *et al.*, 2018). Although negative emotion difficulties are also related to cannabis, alcohol and cigarette use (Hussong *et al.*, 2011) as well as physical aggression (Fanti, 2018), only suicidality was assessed as an outcome in this study.

We aim to (1) examine the developmental patterns of TA and ADT during youth from ages 10 to 16, and (2) investigate both childhood predictors and problematic outcomes (suicidality, physical aggression and substance use) at 16 and 18 years old in the identified joint trajectories.

Method

Study design and sample

Data were based on pooled data from the Longitudinal Studies of Child Abuse and Neglect (LONGSCAN) Consortium. Briefly, the LONGSCAN consortium was formed in 1990 and is composed of one central coordinating center (University of North Carolina) and five independent study sites (Southwestern, $n = 330$; Northwestern, $n = 254$; Eastern, $n = 282$; Southern, $n = 243$ and Midwestern, $n = 245$) in the United States designed to investigate the antecedents and consequences of child maltreatment (total sample = 1354 children). All sites were coordinated for uniform measurement, data collection and entry to improve the ability to compare and pool data. Each site secured human subjects' approval from each site's institutional ethics review boards. All caregivers provided written informed consent and assented for child participants at each interview. Confidentiality of the data was protected by a Federal Certificate of Confidentiality [please see Runyan *et al.* (1998)].

The analyses reported in our study focus on data collected every 2 years at ages 10 through 18 (10, 12, 14, 16 and 18 years old). All 1354 participants were included. The total sample comprised 51.5% girls. Also, the total sample was represented by 53.2% African Americans and 26.1% Caucasians. The study was conducted in accordance with the Transparent Reporting of a multivariable prediction model for Individual Prognosis or Diagnosis (TRIPOD) recommendations (Collins *et al.*, 2015).

Measures

Trajectory analyses

Anxiety-depression trait

Caregivers assessed the level of ADT at ages 10, 12, 14 and 16 by using the Anxious/Depressed subscale of the Child Behavior Checklist (CBCL) (Achenbach, 1991). This widely used subscale consists of 14 items rated on a three-point scale (0 = not true; 1 = somewhat or sometimes true; 2 = very true or often true). The

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internal consistency (Cronbach's αs) for interviews at ages 10–16 ranged from 0.84 to 0.86.

Trait-aggression

Caregivers assessed TA using the Aggressive Behavior subscale of the CBCL (Achenbach, 1991). This subscale consists of 14 items (e.g. destroy things, irritable and temper tantrum) rated on a three-point scale (*idem*). Cronbach's αs for assessments at ages 10–16 ranged from 0.91 to 0.92.

Predictors

Child behavior checklist subscales (CBCL)

An ADHD symptom composite measure was created from nine items derived from the CBCL (Achenbach, 1991), following DSM-5 criteria (American Psychiatric Association, 2013) (online Supplementary Material 1). Internal consistency for the ADHD scale was 0.80. Delinquency (eight items) and social problems (eight items) subscales from the CBCL were used in the current study (Achenbach, 1991). Cronbach's αs were 0.70 and 0.68, respectively. Measures of ADHD symptoms, delinquency and social problems were all assessed at 8 years old.

Childhood abuse

Self-reports of childhood (up to 12 years old) psychological, physical and sexual abuse were assessed retrospectively at 18 years old using an Audio-Computer Assisted Self Interview (A-CASI) delivery system. Self-reports of psychological, physical and sexual abuse were assessed using 18, 15 and 11 questions, respectively. These scales showed acceptable to good internal consistency (i.e. 0.79, 0.62 and 0.88, respectively). Severity of abuse was computed on an ordinal three-point scale (0 = no psychological abuse; 1 = mild to moderate; 2 = moderate to severe). Self-reports for the frequency of each type of abuse (psychological and physical–sexual abuse) was rated on a three-point scale (0 = no self-reports; 1 = 1–2 times; 2 = 3–10 times; 3 = over 10 times) (online Supplementary Material 1).

Control variables

Sociodemographic characteristics

Sociodemographic variables (sex, ethnicity, sites of the assessment, years of education of the caregiver and family income) were assessed at 8 years old. Family income was assessed as the original study, with one item: 'What is the total estimated from all sources after all taxes and deductions are taken out' with responses ranging from 1 to 11 (1 = less than $5000 per year; 11 = more than $50 000 per year, with a $4999 segment for each point on the scale).

Negative outcomes

Violent behaviors

Physical aggression was derived from a 26-item scale measuring the level of delinquency [adapted from Elliott and Huizinga (1983) and Huizinga *et al.* (1991)]. Six items related to physical aggression in the past 12 months were chosen (i.e. hit to hurt, use of a weapon for money to attack people, used weapon for money, involvement in gang fights or physically hurt someone). Cronbach's αs were 0.81 and 0.60 for physical aggression at 16 and 18 years old, respectively. The presence or absence of any of these physically aggressive behaviors in the last 12 months was used in the current study. Suicidality items were derived from the Adolescent Health Status & Service Utilization. Participants were asked if they had seriously considered making suicidal plans or had attempted suicide during the last year (i.e. presence/absence of any of these suicidal behaviors). Dichotomization (i.e. presence or absence of any of these items in the last year) was used in the current study since the base rate of each different behavior was too small to be analyzed separately in subsequent analyses.

Substance use

Substance use was assessed using a LONGSCAN self-report measure on tobacco, alcohol, drugs and involvement in drug-related activities (TADA). This measure is based on items found in the Youth Risk Behavior Survey, Monitoring the Future Study and the CHAMPS Study (Knight *et al.*, 2008). It assesses the presence or absence of substance use during the last year for alcohol, tobacco and cannabis separately.

Analyses

Group-based trajectory modeling

The analyses were achieved in five steps. First, individual trajectory models of ADT and TA were identified by group-based trajectory modeling (GBTM) (step 1). More precisely, we used the PROC TRAJ SAS procedure to fit GBTM for each variable independently (i.e. ADT and TA), in order to assess the optimal number of trajectory groups per variable (Jones *et al.*, 2001). The GBTM allows identifying data-driven longitudinal clusters of individuals following distinct developmental trajectories on a certain variable. Since the GBTM is a data-driven approach, individuals are estimated to follow their respective trajectory group (i.e. cluster) and therefore, cannot switch between trajectory groups within the same construct. Briefly, the model defines the shape of each distinct trajectory (e.g. polynomial order) and extracts the proportion of participants belonging to each trajectory group. To ensure an optimal trajectory analysis, it is recommended that the sample has a baseline and a minimum of one follow-up measurement (Nagin and Tremblay, 2005). Moreover, trajectories were evaluated and chosen, probabilistically, based on several model fit indices such as the Bayesian information criterion, logged Bayes factor, average posterior probabilities (AvePP) and odds of correct classification (OCC) (Jones *et al.*, 2001; Arrandale *et al.*, 2006; Niyonkuru *et al.*, 2013). Finally, it is recommended to use a censored normal (CNORM) model for continuous data that are approximately normally distributed. Furthermore, this distribution model is often used since the data derived from psychometric scale can be clustered at the minimum or at the maximum of a measurement scale. In the current project, considering that data from ADT and TA for 10, 12, 14 and 16 years old were normally distributed (based on Shapiro–Wilk test), we chose the recommendation to use uncensored CNORM model (Jones *et al.*, 2001). See online Supplementary Material 1 for a summary of the trajectory selection process. Refer to the online source (http://www.andrew.cmu.edu/user/bjones/) for more details.

Second, a joint model was estimated using the parameters of trajectory groups identified in step 1. The joint trajectory analysis uses the first trajectory model (ADT) and calculates the probabilities for each trajectory of ADT to be in each trajectory of the second model (TA). This allows calculating the proportion of children estimated to belong simultaneously to ADT and TA trajectories found in the first step (step 2). Third, χ^2 tests and

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analyses of variance were used to assess differences between trajectory groups regarding sociodemographic characteristics (step 3). Statistically significant sociodemographic variables between each trajectory were used as control variables in further analyses. Last, logistic regression analyses were done to predict the group (joint trajectory group) membership (step 4), and to assess the adjustments of each trajectory group at ages 16 and 18 (step 5). An α of 0.005 was chosen to control type-I error rate in statistical analyses performed in steps 4 and 5.

Results

Step 1: identification of ADT and TA trajectories

Only children who completed at least two assessments for ADT and TA were included in the trajectory's analyses ($n = 1079$). Excluded youth did not differ significantly from those who completed two assessments relatively to sex and ethnicity (online Supplementary Table S3). Four trajectories for ADT and two trajectories for TA were considered as the most parsimonious models based on indicators of goodness of fit (online Supplementary Material 1 for a summary of the trajectory selection process). Briefly, the trajectory analyses of ADT (independently of TA) revealed four trajectories: low-ADT (42.2%); moderate ADT (42.8%); increasing ADT (11.9%) and high ADT (3.1%), while the analyses on TA (independently of ADT) identified two trajectories: low-TA (69.9%) and high TA (30.1%) (see online Supplementary Figs S1–S2).

Step 2: joint developmental trajectories of ADT and TA

Children were estimated to belong in a joint trajectory group based on ADT and TA trajectories simultaneously based on parameters of ADT and TA trajectories (step 1). Moreover, trajectory groups of the joint model showed good to excellent AvePP (i.e. ranging from 0.85 to 0.96) and OCC (from 9.41 to 347.9) (see online Supplementary Table S2). Percentages that follow are mixed proportions of joint trajectory groups: 51.8% of the total sample were characterized with low ADT and low TA (LADT-LTA, Fig. 1*a*); 13.3% with moderate ADT and low TA (MADT-LTA, Fig. 1*b*); 21.2% with moderate ADT and high TA (MADT-HTA, Fig. 1*c*); 10.5% with increasing ADT and high TA (IADT-HTA, Fig. 1*d*) and 3.2% with high ADT and high TA (HADT-HTA, Fig. 1*e*). Interestingly, none of the children had increasing levels of ADT and low TA or low ADT and high TA. Only one girl had high ADT and low TA; this individual was excluded from analyses.

To support the validity of these trajectories, we extracted the probabilities for each TA trajectory conditional on a given ADT trajectory and vice versa (online Supplementary Material 1). Briefly, the probability of children with high levels of ADT to display high levels of TA was 0.97, while the probabilities of children with high levels of TA to display moderate, increasing and high levels of ADT were 0.58, 0.31 and 0.58, respectively. Therefore, high TA displays more heterogeneous levels of ADT suggesting that high TA may or may not be associated with high ADT.

Step 3: sociodemographic differences between trajectory groups

Bivariate analyses examining differences between ADT and TA trajectory groups on sociodemographic variables showed that sex, ethnicity and sites statistically differed between trajectory groups ($\chi^2 = 11.62$, $p = 0.020$; $\chi^2 = 53.73$, $p < 0.001$; $\chi^2 = 78.14$, $p < 0.001$, respectively). See online Supplementary Material 2 for complete sociodemographic characteristics of the trajectory groups and pairwise comparisons.

Step 4: childhood predictors of joint ADT and TA trajectory groups

Table 1 presents the multinomial logistic regression results on childhood predictors. All groups (HADT-HTA, IADT-HTA, MADT-HTA and MADT-LTA) were significantly more likely to display higher levels of childhood delinquency, social problems and ADHD symptoms than the LADT-LTA group. Additionally, the IADT-HTA and the HADT-HTA trajectory groups were significantly more likely to have reported more severe and frequent childhood abuse (both psychological and physical–sexual abuse) than their counterpart in the LADT-LTA group. Pairwise comparisons were also performed (online Supplementary Material 3); severity and frequency of childhood psychological abuse significantly predicted a higher risk of following the IADT-HTA trajectory over MADT-HTA [odds ratio (OR) 2.61, 95% confidence interval (CI) 1.41–4.81, $p = 0.002$; OR 1.88, 95% CI 1.21–2.91, $p = 0.005$].

Step 5: negative outcomes of joint trajectory groups

Table 2 presents the results of logistic regressions on negative outcomes at ages 16 and 18 with LADT-LTA as the reference group. The MADT-HTA, IADT-HTA and HADT-HTA trajectory groups, but not the MADT-LTA group, were more likely to display physical aggression at 16 years old. Moreover, adolescents in all trajectories were more likely to show suicidality than adolescents in the LADT-LTA group at 16 years old. Nevertheless, these effects tended to lose statistical significance at 18 years old except for the IADT-HTA trajectory group.

Regarding alcohol use, only adolescents in the MADT-HTA were more likely to use alcohol than in the LADT-LTA group (OR 1.90, 95% CI 1.27–2.84, $p = 0.002$). No statistical differences between trajectory groups were observed at 18 years old regarding alcohol use. Adolescents following the MADT-HTA and IADT-HTA trajectory groups were significantly more likely to use cigarettes at 16 and 18 years old than the adolescent in the LADT-LTA group. Finally, adolescents from all trajectory groups with high TA (HADT-HTA, IADT-HTA and HADT-HTA) were significantly more likely to use cannabis at 16 and 18 years old than adolescents in the LADT-LTA group. Increases in prevalence of substance users, between trajectory groups at 16 and 18 years old are presented in Fig. 2 (see online Supplementary Material 4 for pairwise comparisons).

Discussion

To our knowledge, this is the first study to examine the joint developmental patterns of ADT and TA during adolescence (from ages 10 to 16). In the last decade, researchers have largely studied separately internalizing and externalizing trajectories of psychopathologies (Achenbach *et al.*, 2016). Although this view is accepted in the literature on developmental pathways to problematic behaviors (i.e. substance use, suicidality and violence), it is worth noting that these trajectories are not always mutually exclusive as they can co-occur and predict the development of

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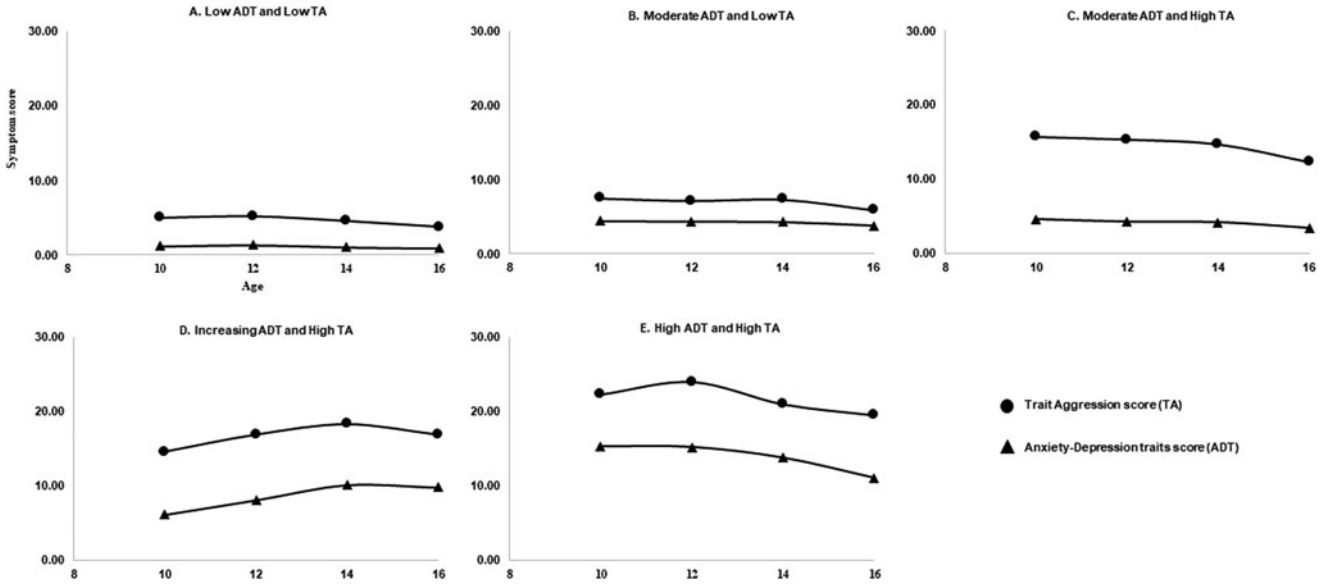


Fig. 1. Developmental groups based on joint trajectories of ADT and TA scores between 10 and 16 years old as assessed by the CBCL: (*a*) LADT-LTA; (*b*) MADT-LTA; (*c*) MADT-HTA and (*d*) IADT-HTA; (e) in front of HADT-HTA.

maladaptive behaviors in adolescence. By using an innovative, data-driven approach (joint trajectory analysis), we found five distinct trajectory groups based on negative affect problems with three of them displaying an overlap between internalizing and externalizing problems (MADT-HTA; IADT-HTA and HADT-HTA). We found that approximately one in three adolescents (34.5%) followed one of these three trajectory groups, which is similar to other findings (Ingoldsby *et al.*, 2006). In adolescents with moderate to high ADT, there was a probability of 0.67–0.99 to display high TA. These results suggest that the overlap between ADT and TA is significant and emphasize the clinical importance of assessing TA in anxious-depressive individuals for a holistic understanding of the psychopathology.

Furthermore, we observed that children having reported higher levels of problems in childhood (ADHD symptoms, social problems and delinquency) and more severe/frequent childhood abuse (psychological and physical–sexual abuse) were significantly more likely to follow trajectories with moderate to high ADT and high TA than trajectory groups with low levels of ADT and TA. Evidence suggests that TA and ADT may arise from shared genetic vulnerabilities, and that environmental risk factors may exacerbate the development of these traits (Azeredo *et al.*, 2018). In fact, extensive literature suggests that shared environmental risk factors such as victimization may lead to autonomic hyper-arousal and negative emotion dysregulation (i.e. negative urgency) (McLaughlin *et al.*, 2009; Dvir *et al.*, 2014; Wardell *et al.*, 2016). Concerning ADHD symptoms, it may represent an important developmental indicator of impulsivity, which is frequently observed in adolescents with externalizing problems and co-occurrent internalizing–externalizing problems (Wolff and Ollendick, 2006; Cunningham and Ollendick, 2010; Nordström *et al.*, 2013; Wardell *et al.*, 2016; Azeredo *et al.*, 2018). Thus, the co-occurrence of impulsivity and negative affect dysregulation [generally referred to as negative urgency (Smith and Cyders, 2016)] may exacerbate the severity and the course of negative-emotion psychopathologies (i.e. ADT and TA) (Nordström *et al.*, 2013).

Another central contribution of this study is the explicit identification of the negative outcomes related to trajectory groups with co-occurring ADT and TA. Children following trajectory groups with high TA and higher ADT were significantly more likely to display violence (suicidality and physical violence) and substance use (cigarette and cannabis) at ages 16 and 18 than those with low levels of ADT and TA. Interestingly, this follows other findings suggesting that the latter co-occurrence may act as an additive effect and may increase significantly the risk of developing substance use problems, physical aggression and suicide attempts in adulthood (Capaldi, 1992; Miller-Johnson *et al.*, 1998; Ezpeleta *et al.*, 2006; Hodgins *et al.*, 2010; McCarty *et al.*, 2013; Orri *et al.*, 2018). It is well known that these three outcomes share several bio-psycho-social predictors, including negative urgency (Mann, 2003; Dumais *et al.*, 2005; Siever, 2008; Dawes *et al.*, 2008). Recent models of urgency have proposed that when experiencing strong negative feelings (e.g. ADT and TA), rash actions may result (substance misuse, physical aggression, suicidal attempts), providing a positive or negative reinforcement of relief (Carver *et al.*, 2008; Smith and Cyders, 2016). Hence, the ADT–TA overlap is likely to be heterogeneous, and more severe forms may increase the severity and the plurality of problematic outcomes associated with intense negative mood (Ezpeleta *et al.*, 2006; Hodgins *et al.*, 2010; McCarty *et al.*, 2013; Orri *et al.*, 2018). Nonetheless, future studies should aim to examine the shared genetic and environmental factors between ADT and TA and the phenotypic outcomes resulting from the co-occurrence within a negative-urgency framework.

Strengths and limitations

The study was derived from a large longitudinal sample of children assessed every 2 years since the age of 4–18. We used an innovative joint trajectory modeling analysis to explore the developmental overlaps between ADT and TA. Nevertheless, there are limitations that should be acknowledged. First, we used dichotomous negative outcomes to assess the overall adjustments of the trajectory groups. Dichotomization of negative outcomes (i.e. presence or absence of behaviors) was used in the current study to reduce the overfitting bias in multinomial regression analyses

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Table 1. Multinomial logistic regression of childhood predictors by trajectory groups ($n = 1078$)

			Statistics[a]	
Childhood predictors	Trajectory groups[b]	Mean (s.d.)	OR (95% CI)	*p* value
ADHD scores[c]	LADT-LTA	3.51 (2.85)	–	–
	MADT-LTA	4.98 (3.04)	**1.18 (1.11–1.26)**	**<0.001**
	MADT-HTA	6.89 (3.50)	**1.38 (1.30–1.46)**	**<0.001**
	IADT-HTA	7.34 (3.43)	**1.42 (1.32–1.52)**	**<0.001**
	HADT-HTA	9.71 (4.47)	**1.69 (1.51–1.90)**	**<0.001**
Social problems[c]	LADT-LTA	1.83 (1.82)	–	–
	MADT-LTA	2.84 (2.06)	**1.29 (1.17–1.43)**	**<0.001**
	MADT-HTA	3.68 (2.52)	**1.50 (1.38–1.63)**	**<0.001**
	IADT-HTA	4.02 (2.66)	**1.58 (1.43–1.74)**	**<0.001**
	HADT-HTA	6.23 (3.26)	**2.00 (1.73–2.31)**	**<0.001**
Delinquent behaviors[c]	LADT-LTA	1.48 (1.55)	–	–
	MADT-LTA	1.93 (1.65)	**1.21 (1.07–1.36)**	**0.002**
	MADT-HTA	3.39 (2.60)	**1.61 (1.47–1.78)**	**<0.001**
	IADT-HTA	3.53 (3.09)	**1.65 (1.48–1.84)**	**<0.001**
	HADT-HTA	5.48 (3.91)	**1.99 (1.99–2.28)**	**<0.001**
Psychological abuse[d]				
Severity	LADT-LTA	0.11 (0.32)	–	–
	MADT-LTA	0.11 (0.35)	0.81 (0.40–1.65)	0.556
	MADT-HTA	0.13 (0.36)	1.06 (0.61–1.85)	0.827
	IADT-HTA	0.33 (0.57)	**2.92 (1.71–4.99)**	**<0.001**
	HADT-HTA	0.55 (0.79)	**4.07 (2.00–8.27)**	**<0.001**
Frequency	LADT-LTA	0.14 (0.46)	–	–
	MADT-LTA	0.13 (0.45)	0.78 (0.46–1.34)	0.365
	MADT-HTA	0.16 (0.50)	1.00 (0.67–1.48)	0.993
	IADT-HTA	0.43 (0.81)	**1.97 (1.36–2.88)**	**<0.001**
	HADT-HTA	0.80 (1.14)	**2.64 (1.63–4.27)**	**<0.001**
Physical–sexual abuse[d]				
Severity	LADT-LTA	0.15 (0.34)	–	–
	MADT-LTA	0.17 (0.33)	0.96 (0.49–1.88)	0.897
	MADT-HTA	0.22 (0.40)	1.38 (0.83–2.29)	0.210
	IADT-HTA	0.30 (0.50)	2.23 (1.24–3.99)	0.007
	HADT-HTA	0.43 (0.60)	**3.18 (1.41–7.19)**	**0.005**
Frequency	LADT-LTA	0.24 (0.58)	–	–
	MADT-LTA	0.22 (0.43)	0.85 (0.55–1.33)	0.484
	MADT-HTA	0.34 (0.63)	1.20 (0.89–1.62)	0.236
	IADT-HTA	0.47 (0.81)	1.65 (1.15–2.36)	0.007
	HADT-HTA	0.61 (0.84)	1.96 (1.15–3.37)	0.014

ADT, anxiety-depression trait; TA, trait-aggression; LADT-LTA, low ADT-low TA; MADT-LTA, moderate ADT-low TA; MADT-HTA, moderate ADT-high TA; IADT-HTA, increasing ADT-high TA; HADT-HTA, high ADT-high TA; OR, odds ratio.
Bolded values represent statistically significant result ($p < 0.005$). No formal correction was made for multiple comparisons.
[a]Adjusted for sex, sites and ethnicity.
[b]LADT-LTA as the reference group.
[c]Assessed at 8 yrs old.
[d]Abuse occurring Before 12 years old.

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Table 2. Multinomial logistic regression of negative outcomes by trajectory groups at 16 and 18 years old ($n = 1078$)

			Age of negative outcome				
			16 years old[a]			18 years old[a]	
Negative outcomes	Trajectory groups[b]	Event rate (%)	OR (95% CI)	*p* value	Event rate (%)	OR (95% CI)	*p* value
Physical aggression	LADT-LTA	17.00	–	–	9.90	–	–
	MADT-LTA	17.80	1.18 (0.67–2.10)	0.563	14.70	1.87 (0.99–3.56)	0.055
	MADT-HTA	30.70	**2.35 (1.52–3.65)**	**<0.001**	12.90	1.23 (0.71–2.20)	0.451
	IADT-HTA	25.60	1.87 (1.04–3.36)	0.072	28.20	**3.84 (2.11–6.99)**	**<0.001**
	HADT-HTA	40.70	**3.97 (1.72–9.19)**	**0.003**	20.80	2.78 (0.95–8.16)	0.063
Suicidality	LADT-LTA	4.70	–	–	3.70	–	–
	MADT-LTA	15.00	3.27 (1.58–6.76)	0.001	4.60	1.06 (0.37–3.02)	0.913
	MADT-HTA	11.40	2.64 (1.33–5.25)	0.006	5.80	1.53 (0.67–3.52)	0.317
	IADT-HTA	23.50	**5.94 (2.88–12.24)**	**<0.001**	12.60	3.04 (1.30–7.09)	0.010
	HADT-HTA	32.10	**8.69 (3.24–23.28)**	**<0.001**	8.00	1.59 (0.33–7.67)	0.564
Alcohol use	LADT-LTA	24.40	–	–	40.00	–	–
	MADT-LTA	32.70	1.31 (0.81–2.12)	0.268	50.50	1.39 (0.90–2.15)	0.138
	MADT-HTA	40.10	**1.90 (1.27–2.84)**	**0.002**	46.20	1.17 (0.80–1.69)	0.420
	IADT-HTA	35.40	1.51 (0.88–2.57)	0.132	48.20	1.21 (0.75–1.97)	0.433
	HADT-HTA	40.70	1.61 (0.70–3.70)	0.259	54.20	1.39 (0.59–3.23)	0.451
Cigarette use	LADT-LTA	15.90	–	–	28.60	–	–
	MADT-LTA	23.40	1.31 (0.76–2.26)	0.329	36.70	1.23 (0.77–1.98)	0.381
	MADT-HTA	35.30	**2.85 (1.83–4.42)**	**<0.001**	52.60	**2.59 (1.76–3.83)**	**<0.001**
	IADT-HTA	41.80	**3.66 (2.12–6.31)**	**<0.001**	55.80	**3.02 (1.83–4.99)**	**<0.001**
	HADT-HTA	35.70	2.15 (0.92–5.07)	0.079	45.80	1.46 (0.61–3.50)	0.395
Cannabis use	LADT-LTA	15.20	–	–	23.90	–	–
	MADT-LTA	23.40	1.57 (0.92–2.68)	0.102	26.60	1.22 (0.75–2.01)	0.422
	MADT-HTA	30.50	**2.23 (1.43–3.46)**	**<0.001**	37.40	**1.83 (1.23–2.72)**	**0.003**
	IADT-HTA	27.80	1.97 (1.11–3.50)	0.022	40.00	**2.26 (1.36–3.74)**	**0.002**
	HADT-HTA	35.70	2.61 (1.12–6.09)	0.026	45.80	2.77 (1.17–6.55)	0.020

ADT, anxiety-depression trait; TA, trait-aggression; LADT-LTA, low ADT-low TA; MADT-LTA, moderate ADT-low TA; MADT-HTA, moderate ADT-high TA; IADT-HTA, increasing ADT-high TA; HADT-HTA, high ADT-high TA; OR, odds ratio.
Bolded values represent statistically significant result ($p < 0.005$). No formal correction was made for multiple comparisons.
[a]Adjusted for sex, sites and ethnicity.
[b]LADT-LTA as the reference group.

since: (1) since the base rates of each different behaviors, separately, were too small and (2) because of the relatively small sizes of subsamples (i.e. trajectory groups). Severity and frequency of violence/suicidal behaviors and substance use should be examined in future studies to support our findings. More details about these outcomes could have increased our ability to detect stronger differences between trajectory groups but also increased our understanding of the implications of joint trajectories of ADT and TA on the development of several disorders in adulthood such as Substance Use Disorders (SUDs) and personality disorders. Second, data on childhood abuse was acquired retrospectively during the interview at the age of 18. However, it has been shown, by using the same sample, that retrospective reports of childhood abuse were concordant with Child Protective Service (CPS) and were also more strongly associated with psychological adjustments than with CPS determinations (Everson *et al.*, 2008). Third, the measure used in the current study assessed severity and frequency of childhood abuses before age of 12. Since trajectory groups were defined on the age range of 10–16 years old, the overlap could have introduced bias in the prediction analysis. However, it is noteworthy to mention that a large majority of childhood abuses generally occurs before the age of 10 (Cammack and Hogue, 2017). Fourth, to reduce common method-variance bias, future studies should seek to use independent measures of ADT and TA, as well as parental and/or teacher reports, in order to replicate findings of this study. Finally, subsequent analyses (i.e. predictors and outcomes) were carried out with the assumption that children were assigned to a single

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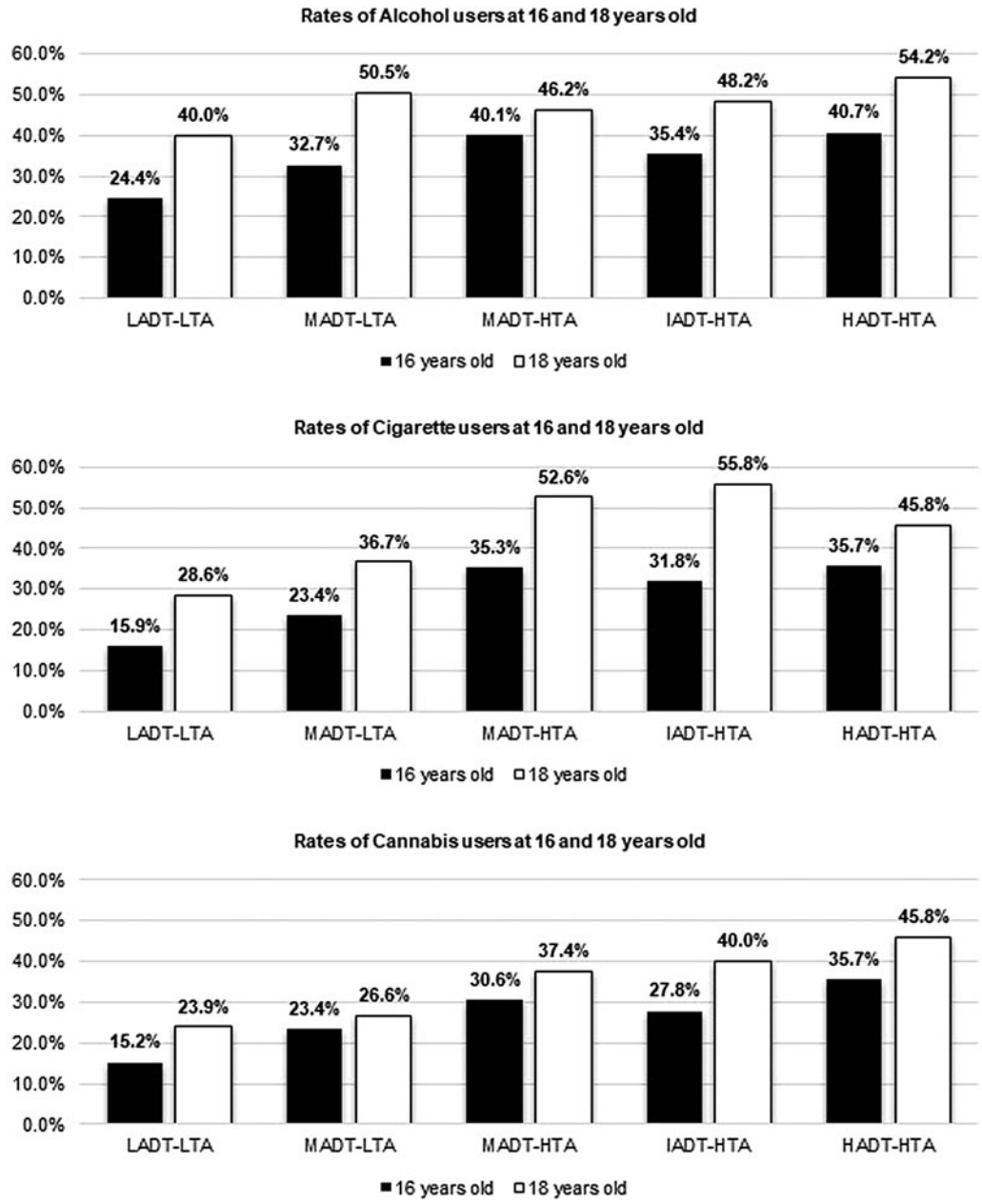


Fig. 2. Changes in prevalence of users of substances between 16 and 18 years old by trajectory groups. ADT, anxiety-depression trait; TA, trait-aggression; LADT-LTA, low ADT-low TA; MADT-LTA, moderate ADT-low TA; MADT-HTA, moderate ADT-high TA; IADT-HTA, increasing ADT-high TA; HADT-HTA, high ADT-high TA.

joint trajectory group (e.g. groups 1, 2, 3, 4 or 5). However, since the joint trajectory group assignment was probabilistic, the assumption used in the current study may have affected statistical inference of subsequent analyses regarding trajectory groups with lower AvePP and OCC. Notwithstanding, our study provided clinically relevant findings about the developmental patterns of affective instability.

Conclusion

By using an innovative approach to understand the co-occurrence of internalizing and externalizing problems, we observed relevant findings for research and clinical practice. While past research on CD has largely focused on callous-unemotional subtypes (First, 2013; Frick, 2016), some promising results suggest that a second variant of CD, predominantly characterized by autonomic over-arousal and emotion dysregulation, is also important (Fanti, 2018). Researchers working on personality disorders in adulthood should be aware of these promising findings (Beauchaine *et al.*, 2009). Finally, future studies with a larger sample size should aim to replicate the current study and investigate the presence of more precise joint trajectories.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0033291719001272.

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Conflict of interest. The authors declare no potential conflicts of interest.

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