# Is there a positive side to sensation seeking? Trajectories of sensation seeking and impulsivity may have unique outcomes in young adulthood

Tomiko Yoneda*, Megan E. Ames, Bonnie J. Leadbeater

*Department of Psychology, University of Victoria, Victoria, V8W 3P5, Canada*

A B S T R A C T

*Introduction:* High levels of sensation seeking and impulsivity in adolescence are typically associated with risky behaviours; limited research has examined the relation of these traits to positive outcomes. Given that adolescence is a sensitive developmental period that can impact success later in life, we adopt the Positive Youth Development Framework to better understand how the development of self-reported sensation seeking and impulsivity may be differentially related to positive markers of early adulthood.

*Method:* Data are from the Victoria Healthy Youth Survey (T1 $N$ = 662; 52% female), a six-wave longitudinal cohort study of Canadian youth. Parallel process latent class growth analysis estimated trajectories of sensation seeking and impulsivity identifying classes of youth (ages 14–28). Controlling for baseline age, sex, and socio-economic status, linear regression analyses examined how longitudinal patterns (classes) of sensation seeking and impulsivity were related to positive markers of early adulthood.

*Results:* Three classes of youth were identified. These varied in levels and trajectories of change in sensation seeking (Ss) and impulsivity (I): LowSs-LowI, 26%; HighSs-HighI, 35%; ModerateSs-LowI, 38%. In young adulthood (T6; ages 22–29), youth in the LowSs-LowI and ModerateSs-LowI classes had significantly higher educational and occupational achievement, and lower financial strain, compared to youth in the HighSs-HighI class. Further, the ModerateSs-LowI class was associated with the highest levels of income and well-being.

*Conclusions:* Findings identified differential trajectories of sensation seeking and impulsivity, with youth in the ModerateSs-LowI class, followed by the LowSs-LowI class, reporting the most positive outcomes in young adulthood.

Adolescence is commonly regarded as a period of turmoil, poor decision making, and reckless behaviour; beliefs that are reinforced by research focusing primarily on risks and negative outcomes in adolescence (Tolan, Ross, Arkin, Godine, & Clark, 2016). Moreover, research suggests that developmental changes in sensation seeking and impulsivity (i.e., low impulse control) during adolescence may account for some of this problematic behaviour (e.g., Shulman, Harden, Chein, & Steinberg, 2016). Sensation seeking is typically characterized as the desire for new and intense experiences and sensations, whereas impulsivity is characterized by the tendency to respond to potential reward with little consideration of consequences (Zuckerman, 1993, 1994).

Longitudinal research shows sensation seeking tends to increase from childhood to adolescence (Steinberg et al., 2008) reaching a peak at approximately 19 years (Steinberg et al., 2018), followed by decreases in early adulthood (Steinberg, 2010). Self-reported

---

impulsivity tends to decrease gradually from childhood through adolescence, before becoming stable in young adulthood (Collado, Felton, MacPherson, & Lejuez, 2014; Harden & Tucker-Drob, 2011; Steinberg et al., 2018). Thus, increasing levels of sensation seeking may encourage adolescents to pursue novelty; a pursuit that may exacerbate risk taking behaviour when paired with a lag in the development of impulse control (e.g., dual systems model; Casey, Jones, & Somerville, 2011; Steinberg, 2010; Strang, Chein, & Steinberg, 2013). Research examining adolescents also shows that sensation seeking and impulsivity, when assessed via self-report measures, are positively associated with cigarette smoking (Lydon-Staley & Geier, 2017), alcohol use (Leeman, Hoff, Krishnan-Sarin, Patock-Peckham, & Potenza, 2014), substance use (Charles et al., 2016), and cannabis use (VanderVeen, Hershberger, & Cyders, 2016). Yet, we know little about the potential positive outcomes associated with these traits. In this study, we examine how homogenous groups of youth based on their co-development of self-reported sensation-seeking and impulsivity are related to positive outcomes in young adulthood. Given the present use of self-reported methods, we primarily focus on summarizing the relevant literature that has measured sensation seeking and impulsivity using self-report indices, as some research shows differences in outcomes based on self-report versus task-based (i.e., behavioural) assessments (Cyders & Coskunpinar, 2011).

Existing research examining sensation seeking and impulsivity in adolescence typically focuses on *average* (i.e., variable-centered) levels and developmental trends of the constructs. Although the traits are moderately correlated at the group level (Collado et al., 2014; Lydon-Staley & Geier, 2017; Moser, Pearson, Hustad, & Borsari, 2014; Shulman et al., 2016; Zuckerman, 1994), neither levels nor developmental patterns of sensation seeking and impulsivity are necessarily similar across all individuals. That is, some individuals may be low in both traits or high in both traits, whereas other individuals may be high in one, but not the other. Thus, individuals with the Low-Low and High-High scores may account for the moderate correlation between the constructs, whereas the divergent combinations of the traits may be ascribed to error variance. Detangling sensation seeking and impulsivity is further complicated given previous research that modeled these constructs as a single factor (e.g., the *Impulsive Sensation Seeking Scale*, Zuckerman-Kuhlman Personality Questionnaire; ZKPQ-III-R; Zuckerman, 2002). However, when sensation seeking and impulsivity are measured as independent constructs, different outcomes are associated with varying levels of the traits (Leeman et al., 2014; Magid, MacLean, & Colder, 2007; Surányi, Hitchcock, Hittner, Vargha, & Urbán, 2013). Specifically, sensation seeking and impulsivity are both related to risk taking; however, compared to sensation seeking, impulsivity is more related to maladaptive risk taking (Fischer & Smith, 2004) as well as negative outcomes, such as illicit drug use (Leeman et al., 2014), gambling (Leeman et al., 2014), alcohol related problems (Magid et al., 2007), alcohol use (Surányi et al., 2013) and smoking (Surányi et al., 2013). Given that differential behaviour and outcomes are related to varying levels of sensation seeking and impulsivity, variable-centered approaches may not be effectively capturing differences in levels and development of the constructs.

Few studies examining sensation seeking and impulsivity have investigated positive behaviours and outcomes (e.g., Mallet & Vignoli, 2007; Surányi et al., 2013), thereby overlooking a further opportunity to understand patterns of adolescent development. Consideration of how levels and development of sensation seeking and impulsivity may relate to positive outcomes aligns with Positive Youth Development (PYD; Lerner, Lerner, Bowers, & Geldhof, 2015). PYD is a strengths-based approach to studying positive development during childhood, adolescence, and young adulthood that is recommended for greater understanding of how the character, personality traits, and strengths of adolescents are associated with their ability to thrive. Indeed, adolescence is a period of rapid developmental change and increased involvement in decision making, and should therefore be regarded as a sensitive developmental period that can impact success later in life (Steinberg, 2005). Consistent with PYD, more nuanced understanding of different developmental patterns of sensation seeking and impulsivity during adolescence, and the role of those differential patterns for positive outcomes later in life, may have implications for the way society views the development of these traits (e.g., typically equating sensation seeking and impulsivity with risky behaviour and negative outcomes).

Consistent with this literature, Romer and associates (2017) proposed an alternative to the dual systems model that distinguishes adaptive and exploratory risk-taking propensities (e.g., sensation seeking) from maladaptive risk-taking propensities (e.g., impulsivity). Referred to as the Lifespan Wisdom Model (Romer, Reyna, & Satterthwaite, 2017), the theory posits that adolescent maladaptive risk taking that is associated with negative outcomes is due to high impulsivity rather than high sensation seeking. Empirical research in support of this model (Khurana, Romer, Betancourt, & Hurt, 2018) used latent class growth analysis to identify classes of individuals based on their developmental trajectories of sensation seeking and two forms of self-reported impulsivity (acting-without-thinking and delay discounting) in a sample of adolescents ($N$ = 387). Findings were consistent with Lifespan Wisdom Theory in the following ways; 1) substance use disorder later in adolescence was limited to a subset of youth characterized by high impulsivity; 2) sensation seeking was not correlated with either measure of impulsivity; and 3) typical increases in sensation seeking did not predict negative outcomes. This longitudinal research emphasizes the importance of characterizing trajectories of sensation seeking and impulsivity at the person-level, rather than based on variable-centered averages.

In the current study, we adopt the PYD framework to better understand how the development of sensation seeking and impulsivity during adolescence and young adulthood (ages 14 to 28) may be related to positive markers of success (i.e., income, educational and occupational achievement, financial strain, and well-being) in young adulthood (ages 22 to 29). Given that development of sensation seeking and impulsivity may be interconnected (Luciana, 2013), trajectories of sensation seeking and impulsivity are included within the same models. Parallel process latent class growth analysis (LCGA; Muthén & Muthén, 2000) identifies homogeneous subpopulations within a heterogeneous sample using unobserved differences in growth trajectories (i.e., intercept and slope) and permits examination of the simultaneous development of both sensation seeking and impulsivity trajectories during adolescence, as well as implications of class membership during adolescence to outcomes in young adulthood. By examining person-centered differences in trajectories of sensation seeking and impulsivity across adolescence, this research also aligns with the Lifespan Wisdom Model. To our knowledge, no study has investigated the possibility of different classes of individuals based on developmental change in trajectories of *both* sensation seeking and impulsivity over time, nor the relation of developmental trajectories of these personality traits to

positive outcomes.

Consistent with research indicating that impulsivity is more related to negative outcomes than sensation seeking (Fischer & Smith, 2004; Khurana et al., 2018; Leeman et al., 2014; Magid et al., 2007), as well as research showing different patterns of sensation seeking are related to positive outcomes (Mallet & Vignoli, 2007; Surányi et al., 2013), we hypothesize that 1) some adolescents will endorse different combinations of sensation seeking and impulsivity (as opposed to the traits being moderately correlated across all adolescents), and 2) moderate to high levels of sensation seeking paired with low to moderate levels of impulsivity will be associated with positive outcomes.

## 1. Method

### 1.1. Participants

Data were drawn from the Victoria Healthy Youth Survey (V-HYS; $N = 662$; 52% female), which was administered biennially from 2003 to 2014 for a total of six measurement occasions (see Leadbeater, Thompson, & Gruppuso, 2012 for further details). The University of Victoria's human research ethics board approved the research protocol. Participants were recruited from a medium-sized Canadian city (Victoria, British Columbia, Canada) using random digit dialing of 9500 telephone listings. At baseline (2003), participants were 12–18 years old ($M$age = 15.5, SD = 1.9). At the final assessment (2013/2014), participants were 22–29 years old ($M$age = 25.8, SD = 2.0).

Attrition analyses compared baseline (T1; ages 12 to 18) demographic variables for participants who remained in the study ($n = 478$) to those who did not have data at T6 ($n = 184$). The proportion of males in the study decreased by 3% (i.e., males at T1 = 48%; male at T6 = 45%) and those who remained in the study had higher SES ($F(1, 636) = 19.39$, $p < .001$). Individuals lost at follow-up had higher baseline levels of sensation seeking ($F(1, 557) = 9.41$, $p = .002$) and higher baseline levels of impulsivity ($F(1, 660) = 5.63$, $p = .02$). Retention rates were high across waves (range 69%–87%).

### 1.2. Procedure

Youth gave written consent and received a gift certificate for participation at each interview. Although parental consent was obtained for youth under age 18, parents were not interviewed. A trained interviewer administered the V-HYS in individual interviews in the youth's home or another private place. To enhance privacy and increase responding, a portion of the V-HYS questionnaire dealing with sensitive topics was completed in private by the participant and placed in a sealed envelope not accessible to the interviewer. All interviews were originally conducted in person, though Skype and phone interviews were used in later waves when necessary to follow youth and young adults who moved or were travelling.

### 1.3. Measures

#### 1.3.1. Dependent variables
*1.3.1.1. Sensation seeking.* Sensation seeking was assessed at T2-T6 using the sensation seeking subscale from the Zuckerman-Kuhlman Personality Questionnaire (ZKPQ; Zuckerman, 2002). Eleven dichotomous (*yes* = 1, *no* = 0) items were summed; e.g., "*I like doing things just for the thrill of it*"; "*I'll try anything once.*" Cronbach's alpha ranged from 0.76 to 0.81 across waves.

*1.3.1.2. Impulsivity.* Impulsivity was assessed using the regulation of attention, impulsivity, and activity subscale of the Brief Child and Family Phone Interview (BCFPI; Cunningham, Boyle, Hong, Pettingill, & Bohaychuk, 2009). Participants were asked to rate six items on a three-point Likert scale ranging from 0 (never) to 2 (often); e.g., "*I am easily distracted or act without stopping to think*". Items were summed (range = 0–12) with higher values representing higher levels of impulsivity. Cronbach's alpha ranged from 0.66 to 0.74 across waves. Assessments from T2-T6 were used match the measurement occasions of sensation seeking.

#### 1.3.2. Predictor variables
Socio-economic status (SES) based on parental SES was used as a covariate in all analyses, consistent with previous research (Steinberg et al., 2008). Parent(s) job titles were ranked from 1 (*menial service workers*) to 9 (*executives/major professionals*) based on the Hollingshead Occupation Status Scale (Bornstein, Hahn, Suwalsky, & Haynes, 2003). The highest occupational prestige for either parent was used. Additionally, all analyses control for self-reported biological sex (Shulman, Harden, Chein, & Steinberg, 2015), included as a dichotomous covariate. Given heterogeneity in age at T1, all analyses control for age centered at mean baseline age.

#### 1.3.3. Outcome variables
Data from T6 were used for outcome variables.

*1.3.3.1. Income.* Participants reported their total personal income for the previous fiscal year, before taxes, from all sources (including tips, commissions, scholarships, and bursaries, but not from student loans). Responses were recoded categorically (0 = no income, 1 = $1 to $4999, 2 = $5000 to $9999, 3 = 10,000 to $14,999, etc.) and ranged 0 to 21. The mean response was 7.6 (SD = 4.9), indicating that the average income was approximately $35,000 to $40,000 for the previous year.

*1.3.3.2. Achievement. Educational attainment.* Participants reported the highest level of education completed (1 = *high school or less*, 2 = *some postsecondary training*, 3 = *trade certificate/diploma*, 4 = *college/university certificate or diploma*, 5 = *bachelor degree or higher*).

*Occupational prestige.* The Youth's Hollingshead Occupational Status Scale (Hollingshead, 1975; also see; Bornstein et al., 2003) was used to assign participant's job title at T6 to one of 9 occupational status categories, equivalent to the parent SES variable.

*1.3.3.3. Financial strain.* Participants were asked three items regarding how often they had troubles paying for (1) basic necessities, (2) items they need for school, college or university, and (3) activities they would like to do. Although response options originally ranged from 0 (*never*) to 2 (*often*), "sometimes" and "often" were collapsed due to limited variability. The items were summed (total range = 0 to 3), with higher values indicating more strain. Cronbach's alpha was .73 at T6.

Participants identified whether financial reasons caused them to delay medical attention, including going to the dentist, doctor visits, filling a medication prescription, or mental health treatment. The four dichotomous items (*yes* = 1; *no* = 0) were summed (range = 0 to 4) to provide a count of delayed medical attention.

*1.3.3.4. Well-being.* The six subscales of Ryff's Psychological Well-Being Inventory (Ryff, 1989) measure self-acceptance (e.g., "*I feel good about who I am*"), positive relations with others (e.g., "*I get a lot out of friendships*"), autonomy (e.g., "*I am not afraid to voice my opinions*"), environmental mastery (e.g., "*I am good at managing my responsibilities*"), purpose in life (e.g., "*I am active in carrying out plans for myself*"), and personal growth (e.g., "*I have developed a lot as a person*"). Each subscale includes nine items rated on a scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Cronbach's alpha of subscales ranged from α = 0.76 for personal growth to α = 0.85 for self-acceptance.

### 1.4. Data analysis

Latent class growth analysis (LCGA; Muthén & Muthén, 2000) uses longitudinal, quantitative techniques uniquely suited for modeling developmental change and focuses on homogeneity among individuals based on response patterns. A parallel process approach allows simultaneous estimation of trajectories of two constructs, resulting in latent classes based on levels and changes in both sensation seeking and impulsivity. The V-HYS included six measurement occasions, though sensation seeking was not measured at baseline. Therefore, the parallel process LCGA included five waves of sensation seeking and impulsivity measurement. The five waves of data (T2-T6) were restructured so that the time metric was age in years from 14 to 28. Data for observations at age 29 were not included in the trajectory analysis due to low coverage covariance ($n = 39$), though data from these individuals at previous ages were included. Unconditional univariate latent growth models were fit to determine the most appropriate shape for development of each trait.

Simulation studies recommend the three-step approach (Asparouhov & Muthén, 2014) for LCGA, in which the number of classes is decided in a model without auxiliary variables (i.e., covariates or distal outcomes). Although some aspects of LCGA have been previously criticized (e.g., the commonality of four prototypic development classes; Sher, Jackson, & Steinley, 2011), the three-step approach ensures auxiliary variables do not impact the number of classes or individuals within each class, thereby avoiding measurement parameter shift problems (Nylund-Gibson, Grimm, Quirck & Furlong, 2014). *Step 1* includes fitting a series of unconditional models in which the number of latent classes was increased by one class with each subsequent model. We followed standard procedure for identifying the best model fit (Muthén & Shedden, 1999) by comparing the values of information criteria fit statistics (i.e., fit statistics provided in Table 1). Significant *p* values for the Vuong-Lo-Mendell-Rubin-adjusted likelihood ratio test (VLMR-LRT) and the bootstrapped likelihood ratio test (BLRT) indicate better model fit compared to the *k*–1 model. Entropy is a measure (range = 0–1) where 1 indicates clear classification of individuals into classes (Celeux & Soromenho, 1996), but an entropy value equal to or greater than 0.6 provides sufficiently good class separation (Asparouhov & Muthén, 2014).

After class identification, *Step 2* includes assigning individuals to latent classes using the logit classification probabilities provided by Mplus (Asparouhov & Muthén, 2014). Using these probabilities ensures that predictor and outcome analyses (i.e., *Step 3*) account for potential class membership error. Multinomial logistic regression analyses were run to examine the association of baseline (T1; ages 12 to 18) demographic variables (age, sex, and SES) with classes of individuals based on trajectories of sensation seeking and impulsivity. Multiple regression analyses were also conducted for distal outcomes (T6; ages 22 to 29) entered into four models: 1)

**Table 1**
Fit statistics for latent class growth analyses for linear trajectories of sensation seeking and impulsivity.

| k | BIC | AIC | VLMR-LRT | BLRT | Entropy |
|---|---|---|---|---|---|
| 1 | 26092.95 | 25931.89 | – | – | – |
| 2 | 25015.43 | 24823.05 | *p* < .001 | *p* < .001 | 0.78 |
| 3 | 24575.45 | 24351.75 | *p* = .006 | *p* < .001 | 0.76 |
| 4 | 24305.35 | 24050.33 | *p* = .675 | *p* < .001 | 0.78 |
| 5 | 24181.23 | 23894.90 | *p* = .218 | *p* < .001 | 0.77 |

Note. K = Number of latent classes; BIC = Bayesian Information Criteria; AIC = Akaike Information Criteria; VLMR-LRT = Vuong-Lo-Mengell-Rubin-adjusted likelihood ratio test; BLRT = bootstrapped likelihood ratio test. Significant *p* values indicate better fit than the previous k – 1 model as assessed by the VLMR-LRT and BLRT.

income; 2) achievement (i.e., educational attainment and occupational prestige); 3) financial strain (i.e., trouble paying and delayed medical attention); and, 4) well-being (i.e., autonomy, environmental mastery, personal growth, positive relations, purpose in life, and self-acceptance). All analyses were run in Mplus Version 8 using full information maximum likelihood estimation with robust standard errors to minimize bias due to missing data (Muthén & Muthén, 1998–2017). All statistical output files, as well as the timing of study concepts, are available on Open Science Framework (URL: https://osf.io/[MASKED]).

## 2. Results

Unconditional univariate latent growth curve models indicated that quadratic, compared to linear, trajectories for sensation seeking ($\chi^2(4) = 37.24, p < .001$) and impulsivity ($\chi^2(4) = 26.54, p < .001$) provided a significantly more parsimonious fit to the data. Both personality traits were therefore specified as quadratic trajectories for the parallel process LCGA.

### 2.1. Parallel process LCGA of sensation seeking and impulsivity

Table 1 presents the fit statistics for class solutions one through five using parallel process LCGA. Although the BIC did not reach a minimum value, there was an identifiable "elbow" (i.e., the last relatively large decrease; Nylund, Asparouhov, & Muthén, 2007), which occurred for the three-class model. Additionally, the VLMR-LRT was significant for the three-class model, but not significant for the four and five class solutions, indicating that the three-class solution was a significantly better fit than the model with an additional class. Thus, the three-class model was chosen because the model fit the data best and the classes represented distinct trajectories of sensation seeking and impulsivity that were consistent with existing literature (Khurana et al., 2018; Leeman et al., 2014; Magid et al., 2007; Surányi et al., 2013). Overall entropy for the three class solution was 0.76, indicating good classification of individuals into discrete classes (Nylund-Gibson, Grimm, Quirk, & Furlong, 2014).

Table 2 summarizes the parameter estimates of the intercepts and slopes of the trajectories. Although developmental trajectories differed between classes, we label the classes by specifying the average *relative* level of each trait at baseline (e.g., low, moderate, high level for a 14-year-old youth). The terminology implies that the intercept for all classes was either low, moderate or high, but all average intercepts were statistically normative (i.e., "low", "moderate" and "high" estimated intercepts were within 1.5 standard deviations of the baseline mean). Fig. 1 (sensation seeking) and Fig. 2 (impulsivity) visually depict the trajectories of the traits by latent class.

Class 1 ($n = 170$; 26%), labelled the *LowSs-LowI* class, included individuals low and relatively stable in both sensation seeking and impulsivity. Class 2 ($n = 229$; 35%), labelled the *HighSs-HighI* class, included individuals high in both sensation seeking and impulsivity at baseline. Individuals in this class showed relative stability in sensation seeking, whereas impulsivity was relatively stable before significantly decreasing. Class 3 ($n = 249$; 38%), labelled the *ModerateSs-LowI* class, included individuals with moderate sensation seeking and low impulsivity at baseline. The adolescents in the ModerateSs-LowI class showed a quadratic trend in sensation seeking, in which levels increased significantly before decreasing, whereas impulsivity was relatively stable. Although we identify this class as "moderate" sensation seeking, it is important to note that these individuals did endorse relatively high levels of sensation seeking during the developmental period (see Fig. 1).

### 2.2. Adolescent correlates (predictors) of sensation seeking and impulsivity classes

Table 3 summarizes the results of the multinomial logistic regression showing associations between baseline (T1; ages 12 to 18) demographic variables and the three trajectory classes. The LowSs-LowI class (70% female) was significantly more likely to be female compared to the HighSs-HighI (44% female) and ModerateSs-LowI (46% female) classes. Although the ModerateSs-LowI class reported significantly higher parental SES compared to the HighSs-HighI class, the LowSs-LowI class was not significantly different from either class. There were no significant age differences between classes.

**Table 2**
Parameter estimates (and standard errors) from unconditional linear latent class growth models for sensation seeking and impulsivity.

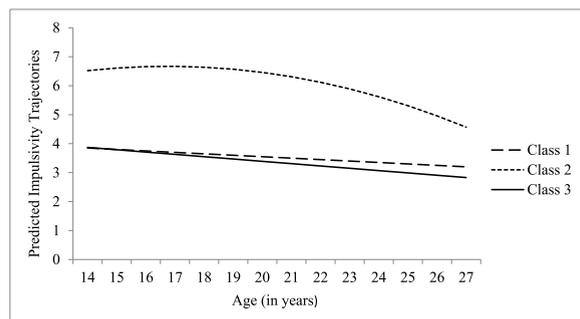|  | Class 1; LowSs-LowI ($n = 170$, 26%) | Class 2; HighSs-HighI ($n = 225$, 35%) | Class 3; ModerateSs-LowI ($n = 253$, 38%) |
|---|---|---|---|
| **Sensation Seeking** |  |  |  |
| Intercept | 4.43 (0.55)*** | 8.06 (0.36)*** | 6.31 (0.46)*** |
| Slope | −0.10 (0.16) | 0.16 (0.11) | 0.43 (0.10)*** |
| Quadratic | 0.00 (0.01) | −0.01 (0.01) | −0.03 (0.001)*** |
| **Impulsivity** |  |  |  |
| Intercept | 3.85 (0.33)*** | 6.52 (0.32)*** | 3.87 (0.29)*** |
| Slope | −0.05 (0.07) | 0.11 (0.08) | −0.08 (0.06) |
| Quadratic | −0.00 (0.01) | −0.02 (0.01) ** | −0.00 (0.00) |

*Note.* LowSs-LowI = Low sensation seeking, low impulsivity; HighSs-HighI = High sensation seeking, high impulsivity; ModerateSs-LowI = Moderate sensation seeking, low impulsivity; Variance is not reported because variance was constrained to zero.
*$p < .05$; **$p < .01$; ***$p < .001$.
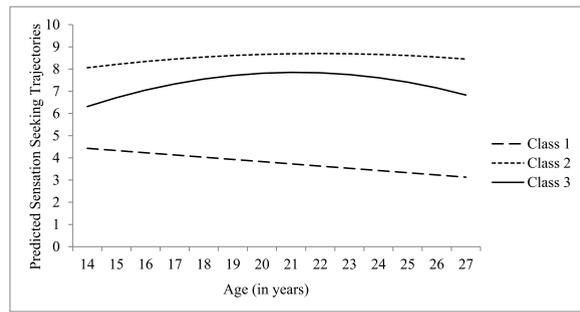
Note. Class 1 = LowSs-LowI, n = 170, 26%, individuals low in sensation seeking and low in impulsivity; Class 2 = HighSs-HighI, n = 229, 35%, individuals high in sensation seeking and high in impulsivity; Class 3 = ModerateSs-HighI, n = 249, 38%, individuals moderate-high in sensation seeking and low in impulsivity.

**Fig. 1.** Plotted latent classes of self-reported sensation seeking trajectories from 14 to 28 years of age. Note. Class 1 = LowSs-LowI, n = 170, 26%, individuals low in sensation seeking and low in impulsivity; Class 2 = HighSs-HighI, n = 229, 35%, individuals high in sensation seeking and high in impulsivity; Class 3 = ModerateSs-HighI, n = 249, 38%, individuals moderate-high in sensation seeking and low in impulsivity.



Note. Class 1 = LowSs-LowI, n = 170, 26%, individuals low in sensation seeking and low in impulsivity; Class 2 = HighSs-HighI, n = 229, 35%, individuals high in sensation seeking and high in impulsivity; Class 3 = ModerateSs-HighI, n = 249, 38%, individuals moderate-high in sensation seeking and low in impulsivity.

**Fig. 2.** Plotted latent classes of self-reported impulsivity trajectories from 14 to 28 years of age. Note. Class 1 = LowSs-LowI, n = 170, 26%, individuals low in sensation seeking and low in impulsivity; Class 2 = HighSs-HighI, n = 229, 35%, individuals high in sensation seeking and high in impulsivity; Class 3 = ModerateSs-HighI, n = 249, 38%, individuals moderate-high in sensation seeking and low in impulsivity.

**Table 3**
Parameter estimates, standard errors, and odds ratios of demographic correlates across sensation seeking and impulsivity classes compared with individuals moderate in sensation seeking and low in impulsivity (class 3; ModerateSs-LowI).

|  | Class 1; LowSs-LowI ($n = 170$, 26%) | | Class 2; HighSs-HighI ($n = 225$, 35%) | | Pairwise Comparison |
|---|---|---|---|---|---|
|  | *Estimate* (*SE*) | OR | *Estimate* (*SE*) | OR | $p < .05$ |
| **Demographics** |  |  |  |  |  |
| Sex | 1.15 (0.26)*** | 3.14 | −0.06 (0.24) | 0.94 | 2, 3 < 1 |
| Age | 0.03 (0.07) | 1.03 | −0.07 (0.07) | 1.08 |  |
| SES | −0.05 (0.08) | 0.95 | −0.16 (0.07)* | 0.86 | 3 > 2 |

*Note. Estimate* = estimated multinomial logistic regression coefficients (*b*); T2 specified as baseline; Ages 14–20; LowSs-LowI = Low sensation seeking, low impulsivity; HighSs-HighI = High sensation seeking, high impulsivity; ModerateSs-LowI = Moderate sensation seeking, low impulsivity; Sex (ref. = male); Age = centered mean age; SES = socioeconomic status. Sample sizes for each trajectory class are based on class assignment using posterior probability of class membership.
*$p < .05$; **$p < .01$; ***$p < .001$.

### 2.3. Young adult correlates (outcomes) of sensation seeking and impulsivity classes

Results summarizing sensation seeking and impulsivity trajectory class differences for income, achievement, financial strain, and well-being in young adulthood (T6; ages 22 to 29) are presented in Table 4. Adjusted means account for sex, baseline age, and SES, as well as the other outcome variables included in each model. Overall Wald tests were used to test overall model significance for each of the four models. Pairwise group comparisons ($p < .05$) were used to assess class trajectory differences when appropriate.

**Table 4**

Adjusted means, standard errors, and probabilities of income, achievement, financial strain and well-being correlates by personality-trait trajectory classes in adolescence and young adulthood (T6; ages 22 to 29).

| Variables | Class 1; LowSs-LowI ($n$ = 170, 26%) | Class 2; HighSs-HighI ($n$ = 225, 35%) | Class 3; ModerateSs-LowI ($n$ = 253, 38%) | Overall Wald | Pairwise Comparison |
|---|---|---|---|---|---|
| | Adjusted mean (SE) | Adjusted mean (SE) | Adjusted mean (SE) | | $p$ < .05 |
| Income | 8.95 (1.00) | 7.98 (0.96) | 10.18 (1.05) | $p$ = .007 | 3 > 2 |
| Achievement | | | | $p$ = .002 | |
|   Educational attainment | 1.96 (0.33) | 1.38 (0.32) | 1.79 (4.41) | | 1, 3 > 2 |
|   Occupational prestige | 4.71 (0.43) | 3.76 (0.40) | 4.41 (0.41) | | 1, 3 > 2 |
| Financial strain | | | | $p$ < .001 | |
|   Trouble paying | 0.49 (0.19) | 1.05 (0.19) | 0.51 (0.20) | | 2 > 3, 1 |
|   Delayed medical attention | 0.15 (0.19) | 0.65 (0.20) | 0.20 (0.18) | | 2 > 3, 1 |
| Ryff's PWB | | | | $p$ < .001 | |
|   Autonomy | 31.95 (1.44) | 32.18 (1.27) | 34.60 (1.38) | | 3 > 2, 1 |
|   Environmental mastery | 32.29 (1.51) | 28.00 (1.38) | 34.28 (1.41) | | 3 > 1 > 2 |
|   Personal growth | 32.40 (1.23) | 34.99 (1.14) | 36.16 (1.15) | | 3, 2 > 1 |
|   Positive relations | 33.86 (1.39) | 33.26 (1.25) | 35.44 (1.32) | | 3 > 1, 2 |
|   Purpose in life | 31.80 (1.49) | 28.97 (1.36) | 33.55 (1.36) | | 3 > 1 > 2 |
|   Self-acceptance | 31.06 (1.43) | 28.79 (1.39) | 33.86 (1.38) | | 3 > 1 > 2 |

Note. LowSs-LowI = low sensation seeking, low impulsivity; HighSs-HighI = High sensation seeking, high impulsivity; ModerateSs-LowI = Moderate sensation seeking, low impulsivity; Ryff's PWB = Ryff's Psychological Well-Being subscales; Models controlled for baseline demographic variables: sex, mean age, and socioeconomic status; Sample sizes for each trajectory class are based on class assignment using posterior probability of class membership.

### 2.3.1. Income

The overall omnibus test of class differences was significant for income; the ModerateSs-LowI class had significantly higher income than the HighSs-HighI class. There were no significant differences between the LowSs-LowI class and either of the other classes.

### 2.3.2. Achievement

The overall omnibus test of class differences was significant for achievement; the LowSs-LowI and ModerateSs-LowI classes did not differ from each other, though both had significantly higher educational attainment and occupational prestige compared to the HighSs-HighI class.

### 2.3.3. Financial strain

The overall omnibus test of class differences was significant for financial strain; the HighSs-HighI class reported significantly higher rates of trouble paying for life expenses and delaying medication attention due to financial reasons compared to the other two classes.

### 2.3.4. Psychological well-being

The overall omnibus test of class differences was significant for well-being. The ModerateSs-LowI class reported significantly higher levels of well-being on five of the six subscales (self-acceptance, positive relations with others, autonomy, environmental mastery, and purpose in life) compared to both the LowSs-LowI and HighSs-HighI classes. For personal growth, the ModerateSs-LowI and HighSs-HighI classes reported significantly higher levels compared to the LowSs-LowI class. Additionally, the LowSs-LowI class reported significantly higher environmental mastery, purpose in life, and self-acceptance compared to the HighSs-HighI class.

## 3. Discussion

To our knowledge, this study is the first to distinguish classes of individuals based on trajectories of both sensation seeking and impulsivity from adolescence to young adulthood. Using parallel process LCGA, we identified three distinct classes of individuals: Class 1 (LowSs-LowI; 26%) included individuals with low, stable levels of both sensation seeking and impulsivity; Class 2 (HighSs-HighI; 35%) included individuals with high stable sensation seeking, and high levels of impulsivity that showed stability before declining; and, Class 3 (ModerateSs-LowI; 38%) included individuals with moderate sensation seeking that increased significantly before declining, and low, stable levels of impulsivity. The identification of these classes supports our hypothesis of varying classes of youth endorsing differential combinations of levels as well as development over time of the personality traits.

### 3.1. Implications for systems of development

Dual systems model theories (Casey et al., 2011; Steinberg, 2010; Strang et al., 2013) propose that differential development of two brain systems during adolescence accounts for age-related increases in risky behaviours. The current study is unable to make

conclusions regarding independent versus interactive systems of neural development based on our analyses or based on self-report indices of sensation seeking and impulsivity; however, our study may assist in explaining the nonsignificant association between the personality traits at the behavioural level in the context of dual systems model theories. Previous research in support of dual systems model highlights individual differences in the rate of developmental change in sensation seeking and impulsivity during adolescence measured by self-report indices by focusing on the small to moderate nonsignificant associations between development of the traits (Harden & Tucker-Drob, 2011) and by showing that change overtime in either sensation seeking or impulsivity is not significantly related to prior level of the other (Shulman et al., 2016). Based on these nonsignificant associations, Harden and Tucker-Drob (2011) and Shulman and associates (2016) conclude that their results indicate independent development of the brain systems due to independent neural correlates. However, results from both papers include a substantial amount of error variance. For example, although the reported associations between linear changes in sensation seeking and impulsivity were small and nonsignificant ($r = 0.21$), large confidence intervals [-0.01, 0.44] are reported (Harden & Tucker-Drob, 2011).

Our results suggest the developmental trajectories of sensation seeking and impulsivity may vary between adolescents; some adolescents show similar developmental patterns in sensation seeking and impulsivity (e.g., the LowSs-LowI class shows relative stability in both traits), while other adolescents show disparate developmental trajectories of the traits (e.g., the ModerateSs-LowI class shows quadratic trends in sensation seeking and relative stability in impulsivity; see Fig. 1). Differential development of the traits between classes of youth may mask associations between changes in sensation seeking and impulsivity (e.g., Harden & Tucker-Drob, 2011), as well as the relation of change overtime in one trait based on prior level of the other trait (e.g., Shulman et al., 2016). When development of the traits are assumed to be universal across individuals (i.e., variable-centered), tests of relative prospective growth between the traits may be reduced to that of nonsignificance due to error variance, though the possibility is highly dependent on the generalizability of our results.

### 3.2. Positive young adult correlates of classes of sensation seeking and impulsivity

Lerner and associates' (2015) emphasize that the PYD framework is a philosophy that highlights the strengths and characteristics of youth that foster thriving, as opposed to the traditional deficit model of adolescence. Using the PYD perspective, we examined markers of success in young adulthood (T6; ages 22 to 29) associated with the three classes. Results show youth in the LowSs-LowI and ModerateSs-LowI classes reported significantly higher educational and occupational achievement and lower financial strain compared to youth with high levels of both traits. Consistent with previous research showing that sensation seeking and impulsivity are positively related to negative outcomes, individuals in the HighSs-HighI class had the lowest income and educational attainment, and the highest financial strain. In contrast, the ModerateSs-LowI and LowSs-LowI classes did not significantly differ from each other in terms of income and educational attainment, despite between-class variation in levels and development of sensation seeking in adolescence. In addition to the highest income, good achievement, and low financial strain, individuals in the ModerateSs-LowI class also demonstrated significantly higher levels of self-acceptance, positive relations with others, autonomy, environmental mastery, and purpose in life compared to the other two classes of individuals. These results support and surpass our hypothesis that moderate to high levels of sensation seeking paired with low to moderate levels of impulsivity would be associated with positive outcomes by showing that the differential development class (i.e., ModerateSs-LowI) was associated with the most positive outcomes.

Very few studies have examined sensation seeking and impulsivity in the context of positive behaviour or outcomes, but results from the limited research in this area is consistent with our findings. For example, previous research examining the relation of sensation seeking and impulsivity to vocational interests found that sensation seeking, but not impulsivity, was related to interests in jobs that involve danger for the purpose of saving lives (e.g., firefighting) and jobs that require creativity and imagination (Mallet & Vignoli, 2007). Further, longitudinal research examining the role of self-control (i.e., ability to avoid impulsivity; Vohs & Baumeister, 2016) on success in middle adulthood showed that childhood self-control was positively related to wealth, credit rating, positive parenting, well-being and life satisfaction at age 38, beyond differences in intelligence and SES (Moffitt, Poulton, & Caspi, 2013). At first glance, these findings seem consistent with our results, but the comparison is challenging because Moffitt and colleagues did not assess sensation seeking. Our results are partially consistent with Moffitt's work by showing that low impulsivity (i.e., high self-control) is associated with many positive outcomes. Together, these results seem to imply that it may be *low impulsivity* that is consistently related to markers of success. However, we see an important distinction within our findings; namely, although low impulsivity (e.g., adolescents in the LowSs-LowI and ModerateSs-LowI classes) consistently predicts markers of success (e.g., high achievement and low financial strain), the ModerateSs-LowI class was also associated with significantly higher well-being, across all six dimensions, compared to the LowSs-LowI class. These findings suggest that development of sensation seeking in adolescence may be important for *subjective* markers of success. Moffitt et al. (2013) did not examine sensation seeking in adolescence, but it is possible that sensation seeking measured in adolescence may further distinguish children with high self-control on measures of well-being and life satisfaction in middle adulthood.

Our results show that sensation seeking, if indulged in appropriate circumstances (i.e., without impulsivity), may particularly foster positive life outcomes. Although sensation seeking and impulsivity are not entirely influenced by environmental factors, endorsement of low sensation seeking and impulsivity across development is likely associated with persistent direction to follow the rules and avoid risk, consistent with traditional societal views that equate sensation seeking and impulsivity with risk and negative outcomes (Charles et al., 2016; Leeman et al., 2014; Lydon-Staley & Geier, 2017; VanderVeen et al., 2016). Such insistent direction may not objectively impact these adolescents negatively; however, subjective success (e.g., well-being) may be detrimentally impacted. Advancement of a social context that encourages adolescents to explore novel experiences and sensations in the context of thoughtful decision making may empower adolescents to develop in a way that will support both objective and subjective success

later in life. Consistent with PYD, which advocates for research that informs programs and education focused on promoting positive development of adolescents (Lerner et al., 2015), our findings may have substantive implications for the way society views risky behaviour and the development of these traits during adolescence.

### 3.3. Limitations and future directions

All data were self-report, which could contribute to a shared reporter variance that increases correlations among the variables. Selective attrition may have resulted in underestimating associations, as participants who dropped out of the study were more likely to have higher levels of sensation seeking and impulsivity at earlier measurement occasions. Further, sex at T1 with dichotomous response options was included as a covariate, which masks the ability to assess individuals who self-identify as intersex or gender diverse.

The data used for the current analysis may be limited to generalizing to predominately Caucasian, Canadian samples of adolescents, though cross-cultural findings regarding sensation seeking and impulsivity are mixed. For example, Duell and associates (2016) recently showed cultural differences in the predictive role of sensation seeking and impulsivity on risk taking. Conversely, Steinberg et al. (2018) showed that developmental patterns of the traits measured by self-report and behavioural-based tasks are remarkably similar across cultures. Thus, consideration of culture and social context may be important. Suleiman, Galván, Harden, and Dahl (2017) recently discussed how cultural and social factors play a critical role in development during adolescence. This concept may be applicable to our research because some aspects of sensation seeking (e.g., liking exciting experiences or spontaneous trips) may be viewed positively within Western society and individuals may be rewarded for taking some risks, while other cultures may not consider aspects of sensation seeking to be positive. Relatedly, the V-HYS is a community-based normative sample, and results may not be generalizable to clinical samples.

Consistent with previous research (Thompson, Roemer, & Leadbeater, 2015), we operationalized impulsivity as self-reported scores on the regulation of attention, impulsivity, and activity subscale of the BCFPI. However, impulsivity is a complex and multi-faceted construct. A vigorous meta-analysis comparing impulsivity assessed via self-report versus behavioural lab tasks found a small, though statistically significant, overlap between the methods (Cyders & Coskunpinar, 2011), indicating that the different types of tasks may be measuring different constructs. A further meta-analysis conducted by Duckworth and Kern (2011) revealed stronger convergent validity for informant- and self-report indices of self-control, compared to behavioural tasks. The authors suggested that questionnaire items may be more appropriate for soliciting an overall opinion of behaviour across multiple situations compared to performance in a single situation (Duckworth & Kern, 2011). In addition, measurement of sensation seeking included dichotomous items from a subscale of the Zuckerman-Kuhlman Personality Questionnaire (Zuckerman, 2002). Although this scale is frequently used in the literature to assess sensation seeking (e.g., see meta-analysis by Hittner & Swickert, 2006), future work using more robust measures or latent factors of both sensation seeking and impulsivity, as well as comparison of different types of assessments (e.g., self-report, informant-report, task-based), may yield stronger findings.

## 4. Conclusion

Building upon and extending our understanding of typical levels of and changes in sensation seeking and impulsivity, our findings show that the combination of high sensation seeking paired with low impulsivity across adolescence is related to many positive outcomes in young adulthood. Our hypotheses were supported by the classes identified by the parallel process LGCA, as well as by the pattern of outcomes related to the classes. Our results are consistent with existing research showing high sensation seeking and high impulsivity are related to negative outcomes in adolescence (Charles et al., 2016; Hu et al., 2017; Lydon-Staley & Geier, 2017; VanderVeen et al., 2016), as well as research showing that impulsivity may be more related to negative outcomes than sensation seeking (Fischer & Smith, 2004; Leeman et al., 2014; Magid et al., 2007; Surányi et al., 2013).

Consistent with recommendations by Luciana, our results highlight that the constructs may be dynamically related and that patterns of the traits may vary across individuals, exemplifying the importance of characterizing trajectories of sensation seeking and impulsivity at the person-level. Our results also support and complement the Lifespan Wisdom Model (Khurana et al., 2018; Romer et al., 2017) by showing that high levels of impulsivity are characteristic of a subset of individuals, and that relatively moderate to high sensation seeking, when paired with relatively low impulsivity, may be related to many positive outcomes in young adulthood, including high income, achievement, and well-being.

## Disclosures

Declarations of interest: none. Competing interests: none. This study was not pre-registered as the original paper was completed as

part of graduate course; however, a timeline of concepts and all of the Mplus output files are available on Open Science Framework [URL: https://osf.io/6vcnu/]. V-HYS data are not openly available due to lack of permission. Author contributions: Tomiko Yoneda conceptualized the research questions, conducted all statistical analyses, and wrote the manuscript; Megan E. Ames assisted with manuscript writing and editing, and consulted on statistical analysis; Bonnie Leadbeater is the principal investigator of Victoria Healthy Youth Survey (V-HYS) directing study design and data collection; for the present study, she assisted with the conceptualization and manuscript editing.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.adolescence.2019.03.009.

## References

Asparouhov, T., & Muthén, B. (2014). Auxiliary variables in mixture modeling: Three-step approaches using Mplus. *Structural Equation Modeling: A Multidisciplinary Journal, 21*(3), 1–13. https://doi.org/10.1080/10705511.2014.915181.

Bornstein, M. H., Hahn, C. S., Suwalsky, J. T. D., & Haynes, O. M. (2003). Socioeconomic status, parenting, and child development: The Hollingshead four-factor index of social status and the socioeconomic index of occupations. In M. H. Bornstein, & R. H. Bradley (Eds.). *Socioeconomic status, parenting, and child development* (pp. 29–82). Mahwah: Lawrence Erlbaum Publishers.

Casey, B. J., Jones, R. M., & Somerville, L. H. (2011). Braking and accelerating of the adolescent brain. *Journal of Research on Adolescence, 21*(1), 21–33. https://doi.org/10.1111/j.1532-7795.2010.00712.x.

Celeux, G., & Soromenho, G. (1996). An entropy criterion for assessing the number of clusters in a mixture model. *Journal of Classification, 13*, 195–212. https://doi.org/10.1007/BF01246098.

Charles, N. E., Ryan, S. R., Bray, B. C., Mathias, C. W., Acheson, A., & Dougherty, D. M. (2016). Altered developmental trajectories for impulsivity and sensation seeking among adolescent substance users. *Addictive Behaviors, 60*, 235–241. https://doi.org/10.1016/j.addbeh.2016.04.016.

Collado, A., Felton, J., MacPherson, L., & Lejuez, C. (2014). Longitudinal trajectories of sensation seeking, risk taking propensity, and impulsivity across early to middle adolescence. *Addictive Behaviors, 39*(11), 1580–1588. https://doi.org/10.1016/j.addbeh.2014.01.024.

Cunningham, C., Boyle, M., Hong, S., Pettingill, P., & Bohaychuk, D. (2009). The brief child and family phone interview (BCFPI): 1. Rationale, development, and description of a computerized children's mental health intake and outcome assessment tool. *Journal of Child Psychology and Psychiatry, 50*(4), 416–423. https://doi.org/10.1111/j.1469-7610.2008.01970.x.

Cyders, M. A., & Coskunpinar, A. (2011). Measurement of constructs using self-report and behavioral lab tasks: Is there overlap in nomothetic span and construct representation for impulsivity? *Clinical Psychology Review, 31*(6), 965–992. https://doi.org/10.1016/j.cpr.2011.06.001.

Duckworth, A. L., & Kern, M. L. (2011). A meta-analysis of the convergent validity of self-control measures. *Journal of Research in Personality, 45*(3), 259–268. https://doi.org/10.1016/j.jrp.2011.02.004.

Duell, N., Steinberg, L., Chein, J., Al-Hassan, S., Bacchini, D., Lei, C., & Alampay, L. P. (2016). Interaction of reward seeking and self-regulation in the prediction of risk taking: A cross-national test of the dual systems model. *Developmental Psychology, 52*(10), 1593–1605. https://doi.org/10.1037/dev0000152.

Fischer, S., & Smith, G. T. (2004). Deliberation affects risk taking beyond sensation seeking. *Personality and Individual Differences, 36*(3), 527–537. https://doi.org/10.1016/S0191-8869(03)00112-0.

Harden, K. P., & Tucker-Drob, E. M. (2011). Individual differences in the development of sensation seeking and impulsivity during adolescence: Further evidence for a dual systems model. *Developmental Psychology, 47*(3), 739–746. https://doi.org/10.1037/a0023279.

Hittner, J. B., & Swickert, R. (2006). Sensation seeking and alcohol use: A meta-analytic review. *Addictive Behaviors, 31*(8), 1383–1401. https://doi.org/10.1016/j.addbeh.2005.11.004.

Hollingshead, A. B. (1975). *Four factor index of social status.* New Haven: Department of Sociology, Yale University Unpublished manuscript.

Khurana, A., Romer, D., Betancourt, L. M., & Hurt, H. (2018). Modeling trajectories of sensation seeking and impulsivity dimensions from early to late adolescence: Universal trends or distinct sub-groups? *Journal of Youth and Adolescence, 47*(9), 1992–2005. https://doi.org/10.1007/s10964-018-0891-9.

Leadbeater, D., Thompson, K., & Gruppuso, V. (2012). Co-occurring trajectories of symptoms of anxiety, depression, and oppositional defiance from adolescence to young adulthood. *Journal of Clinical Child and Adolescent Psychology, 41*, 719–730. https://doi.org/10.1080/15374416.2012.694608.

Leeman, R., Hoff, R., Krishnan-Sarin, S., Patock-Peckham, J., & Potenza, M. (2014). Impulsivity, sensation-seeking, and part-time job status in relation to substance use and gambling in adolescents. *Journal of Adolescent Health, 54*(4), 460–466. https://doi.org/10.1016/j.jadohealth.2013.09.014.

Lerner, R. M., Lerner, J. V., Bowers, E., & Geldhof, G. J. (2015). Positive youth development: A relational developmental systems model. In W. F. Overton, & P. C. Molenaar (Vol. Eds.), (7ᵗʰ ed.). R. M. Lerner, & N. J. Hoboen (Vol. Eds.), *Handbook of child psychology and developmental science: Vol. 1*, (pp. 608–651). Wiley Theory and method.

Luciana, M. (2013). Adolescent brain development in normality and psychopathology. *Development and Psychopathology, 25*(4 Pt 2), 1325–1345. https://doi.org/10.1017/S0954579413000643.

Lydon-Staley, D. M., & Geier, C. F. (2017). Age-varying associations between cigarette smoking, sensation seeking, and impulse control through adolescence and young adulthood. *Journal of Research on Adolescence*. https://doi.org/10.1111/jora.12335.

Magid, V., MacLean, M. G., & Colder, C. R. (2007). Differentiating between sensation seeking and impulsivity through their mediated relations with alcohol use and problems. *Addictive Behaviors, 32*(10), 2046–2061. https://doi.org/10.1016/j.addbeh.2007.01.015.

Mallet, P., & Vignoli, E. (2007). Intensity seeking and novelty seeking: Their relationship to adolescent risk behavior and occupational interests. *Personality and Individual Differences, 43*(8), 2011–2021. https://doi.org/10.1016/j.paid.2007.06.018.

Moffitt, T. E., Poulton, R., & Caspi, A. (2013). Lifelong impact of early self-control. *American Scientist, 101*(5), 352–359. https://doi.org/10.1511/2013.104.352.

Moser, K., Pearson, M. R., Hustad, J. T. P., & Borsari, B. (2014). Drinking games, tailgating, and pregaming: Precollege predictors of risky college drinking. *The American Journal of Drug and Alcohol Abuse, 40*(5), 367–373. https://doi.org/10.3109/00952990.2014.936443.

Muthén, B., & Muthén, L. (1998-2017). *Mplus user's guide* (8th ed.). Los Angeles, CA: Muthén & Muthén.

Muthén, B., & Muthén, L. (2000). Integrating person-centered and variable-centered analyses: Growth mixture modeling with latent trajectory classes. *Alcoholism-Clinical and Experimental Research, 24*(6), 882–891. https://doi.org/10.1097/00000374-200006000-00020.

Muthén, B., & Shedden, K. (1999). Finite mixture modeling with mixture outcomes using the EM algorithm. *Biometrics, 55*(2), 463–469.

Nylund-Gibson, K., Grimm, R., Quirk, M., & Furlong, M. (2014). A latent transition mixture model using the three-step specification. *Structural Equation Modeling: A Multidisciplinary Journal, 21*(3), 439–454. https://doi.org/10.1080/10705511.2014.915375.

Nylund, K. L., Asparouhov, T., & Muthén, B. O. (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Structural Equation Modeling: A Multidisciplinary Journal, 14*(4), 535–569. https://doi.org/10.1080/10705510701575396.

Romer, D., Reyna, V. F., & Satterthwaite, T. D. (2017). Beyond stereotypes of adolescent risk taking: Placing the adolescent brain in developmental context. *Developmental Cognitive Neuroscience, 27*, 19–34. https://doi.org/10.1016/j.dcn.2017.07.007.

Ryff, C. D. (1989). Happiness is everything, or is it? Explorations on the meaning of psychological well-being. *Journal of Personality and Social Psychology, 57*(6), 1069–1081. https://doi.org/10.1037/0022-3514.57.6.1069.

Sher, K., Jackson, K., & Steinley, D. (2011). Alcohol use trajectories and the ubiquitous cat's cradle: Cause for concern? *Journal of Abnormal Psychology, 120*(2),

322–335. https://doi.org/10.1037/a002181.

Shulman, E. P., Harden, K. P., Chein, J. M., & Steinberg, L. (2015). Sex differences in the developmental trajectories of impulse control and sensation-seeking from early adolescence to early adulthood. *Journal of Youth and Adolescence, 44*(1), 1–17. https://doi.org/10.1007/s10964-014-0116-9.

Shulman, E. P., Harden, K. P., Chein, J. M., & Steinberg, L. (2016). The development of impulse control and Sensation-Seeking in adolescence: Independent or interdependent processes? *Journal of Research on Adolescence, 26*(1), 37–44. https://doi.org/10.1111/jora.12181.

Steinberg, L. (2005). Cognitive and affective development in adolescence. *Trends in Cognitive Sciences, 9*(2), 69–74. https://doi.org/10.1016/j.tics.2004.12.005.

Steinberg, L. (2010). A dual systems model of adolescent risk-taking. *Developmental Psychobiology, 52*(3), https://doi.org/10.1002/dev.20445 216-n/a.

Steinberg, L., Albert, D., Cauffman, E., Banich, M., Graham, S., & Woolard, J. (2008). Age differences in sensation seeking and impulsivity as indexed by behavior and self-report: Evidence for a dual systems model. *Developmental Psychology, 44*(6), 1764–1778. https://doi.org/10.1037/a0012955.

Steinberg, L., Icenogle, G., Shulman, E. P., Breiner, K., Chein, J., & Bacchini, D. (2018). Around the world, adolescence is a time of heightened sensation seeking and immature self-regulation. Institutionen för individ och samhälle *Developmental Science, 21*(2), https://doi.org/10.1111/desc.12532 e12532-n/a.

Strang, N. M., Chein, J. M., & Steinberg, L. (2013). The value of the dual systems model of adolescent risk-taking. *Frontiers in Human Neuroscience, 7*, 223. https://doi.org/10.3389/fnhum.2013.00223.

Suleiman, A. B., Galván, A., Harden, K. P., & Dahl, R. E. (2017). Becoming a sexual being: The 'elephant in the room' of adolescent brain development. *Developmental Cognitive Neuroscience, 25*, 209–220. https://doi.org/10.1016/j.dcn.2016.09.004.

Surányi, Z., Hitchcock, D. B., Hittner, J. B., Vargha, A., & Urbán, R. (2013). Different types of sensation seeking: A person-oriented approach in sensation-seeking research. *International Journal of Behavioral Development, 37*(3), 274–285. https://doi.org/10.1177/0165025413483221.

Thompson, K., Roemer, A., & Leadbeater, B. (2015). Impulsive personality, parental monitoring, and alcohol outcomes from adolescence through young adulthood. *Journal of Adolescent Health, 57*(3), https://doi.org/10.1016/j.jadohealth.2015.05.005.

Tolan, P., Ross, K., Arkin, N., Godine, N., & Clark, E. (2016). Toward an integrated approach to positive development: Implications for intervention. *Applied Developmental Science, 20*(3), 214–236. https://doi.org/10.1080/10888691.2016.1146080.

VanderVeen, J. D., Hershberger, A. R., & Cyders, M. A. (2016). UPPS-P model impulsivity and marijuana use behaviors in adolescents: A meta-analysis. *Drug and Alcohol Dependence, 168*, 181–190. https://doi.org/10.1016/j.drugalcdep.2016.09.016.

Vohs, K. D., & Baumeister, R. F. (2016). *Handbook of self-regulation: Research, theory, and applications* (3rd ed.). New York: The Guilford Press.

Zuckerman, M. (1993). Sensation seeking and impulsivity: A marriage of traits made in biology? In W. G. McCown, J. L. Johnson, & M. B. Shure (Eds.). *The impulsive client: Theory, research, and treatment* (pp. 71–91). Washington, DC: American Psychological Association.

Zuckerman, M. (1994). *Behavioral expressions and biosocial bases of sensation seeking.* Cambridge, England: Cambridge University Press.

Zuckerman, M. (2002). Zuckerman-Kuhlman Personality Questionnaire (ZKPQ): An alternative five-factorial model. In B. DeRaad, & M. Perusini (Eds.). *Big five assessment. Seattle.* Hogrefe and Huber Publishers.