



Research article

Childhood experiences and adult health: the moderating effects of temperament



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ABSTRACT

Existing literature demonstrates a strong relationship between childhood experiences and adult health outcomes. The Differential Susceptibility to Environment Theory suggests that there are several factors, including personality, that affect a child's sensitivity to adverse and advantageous experiences. A sample of 246 adults (ages 19–57) were asked questions about extroverted personality characteristics, adverse and advantageous childhood experiences (ACEs and counter-ACEs), and several indicators of adult health, including executive functioning, perceived stress levels, depression, and past smoking habits. The sample was then stratified based on level of extroversion scores with the top quartile being labeled as “extroverts”, the bottom quartile as “introverts”, and those in between as “ambiverts”. Regression analyses were then used to assess the relationship between childhood experiences and each adult health outcome. The results of the study showed that the relationship between childhood experiences and adult health was generally stronger among extroverted individuals. These results suggest that extroverts may be more sensitive to environmental influences in childhood as compared to introverts and ambiverts. More research is needed to understand the neurobiological mechanisms that increase environmental sensitivity among extroverts.

1. Introduction

ACEs are negative events experienced during childhood including abuse, neglect, and household dysfunction. In their foundational research on adverse childhood experiences (ACEs), Felitti et al. (1998) examined the effects of ACEs on adult health and observed that experiencing four or more ACEs was associated with significant increases in drug abuse, mental illness, and other leading causes of death in adulthood. Several other studies conducted within the last two decades have likewise demonstrated that ACEs predicted adverse mental and physical health in adulthood (see for example Dong et al., 2003; Karatekin, 2019; Chang et al., 2019; Bellis et al., 2019). More recently, research on ACEs has assessed the severity of traumatic childhood experiences to inform prevention programs targeted at reducing childhood stress (Larkin et al., 2014). Merrick et al. (2018) also observed the negative impact of ACEs on adult health and found the relationship to be stronger among at risk populations, such as those living in poverty, people of color, and members of the LGBTQ community. Other areas of research on childhood experience have also emerged, such as the positive effect of advantageous childhood experiences, or counter-ACEs, on adult health irrespective of

ACEs. Current research shows that Counter-ACEs build resilience and provide children with necessary coping mechanisms and support systems to overcome difficult experiences (Crandall et al., 2019; Bethell et al., 2019; Narayan et al., 2018).

1.1. Differential Susceptibility to the Environment Theory

While existing literature demonstrates a strong relationship between childhood experiences and adult health outcomes, the effects of childhood experiences on adult health may vary due to differences in neurobiological development (Ellis et al., 2011). Research indicates that children differ not only in their susceptibility to ACEs, but also in the degree to which they are affected by positive environmental influences (Caspi et al., 2002, 2003; Lippard and Nemeroff, 2020). For example, in one study (Bakermans-Kranenburg and Van Ijzendoorn, 2011), it was observed that children with a genetic disposition for decreased sensitivity to dopamine experienced more negative outcomes after negative experiences as well as more positive outcomes after positive experiences, significantly more so than children with normal levels of dopamine sensitivity.

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The Differential Susceptibility to Environmental Theory (DSE) suggests that evolution has maintained the genotypes for two physiological mechanisms for optimal adaptation to environmental changes: conditional adaptation and alternative adaptation. Conditional adaptation allows an individual to be shaped by their environment and experiences and suggests a greater sensitivity to positive and negative experiences (Rowe et al., 1997). Contrarily, individuals who employ alternative adaptation strategies are not as easily molded by experience, which suggests less sensitivity to positive and negative childhood experiences (Ellis et al., 2011; Patch and Figueredo, 2017).

The DSE helps to explain why children vary so widely in their sensitivity to positive and negative experiences, but a critical next step is to identify those characteristics that distinguish more sensitive children from those who are less sensitive. Early attempts to identify markers of increased susceptibility suggested that children with a difficult or more reactive temperament might be more sensitive to positive and negative experiences (Belsky et al., 1998; Krieger and Stringaris, 2016; Lengua et al., 2019). Another aspect of childhood temperament that may impact childhood environmental sensitivity is the tendency toward extroverted behaviors.

1.2. Temperament, childhood experiences, and adult health

Introversion and extroversion are among the oldest traits discussed in personality theories (see for example Freyd, 1924; Jung, 1917). Definitions of extroversion/introversion vary across studies, but function most often as umbrella terms to explain extremes on a spectrum of personality characteristics. Extroversion is commonly defined as an aspect of personality characterized by focus of interests on the external world (Bhargava et al., 2015). Extroversion is most typically associated with optimism, high sensitivity to environmental stimuli, externalizing behaviors, and high situational adaptability (Wilt and Revelle, 2017). Several studies have found lower extroversion scores correlated with higher depression scores (Grav et al., 2012), higher perceived stress scores (Ebstrup et al., 2011), and better cognitive flexibility and working memory (Campbell et al., 2011). Contrarily, introversion is commonly defined as an aspect of personality characterized by concentration on inner psychic activity and is associated with being stimulated by deep thought or pondering as well as, mindfulness, emotional control, and internalizing behaviors (Bhargava et al., 2015; Li et al., 2018; Guilford, 1934). In between introversion and extroversion on the personality spectrum is ambiversion. Ambiverts are those possessing a mixture of extroverted and introverted characteristics (Francis et al., 2017). Depending on context, ambiverts have been observed in some studies to employ introverted tendencies, such as introspection or listening, as well as extroverted ones, such as assertiveness or enthusiasm depending on situation (Grant, 2013).

An extensive pool of research indicates that extroverted/introverted personality characteristics stem from differences in physiological development. According to the DSE, extroverts probably employ conditional adaptation strategies and are more likely to be affected by both adverse and advantageous childhood experiences. This is because extroverts have a more reactive sympathetic nervous system, which may prompt more frequent interaction with their surroundings and externalization of their thoughts and feelings (Lester, 2010). Contrarily, introverts are most likely going to be less affected by their interactions with their environment, possibly are less reliant on their surroundings for stimulation or satisfaction and are often more content pondering or thinking alone rather than interacting with their environment (Li et al., 2018). Additionally, introverts are more able to maintain emotional equanimity in the presence of both positive and negative stimuli (Radzi et al., 2019). Studies exploring physiological characteristics of ambiverts vary widely and show that physiological characteristics of ambiverts, such as autonomic nervous activity or cortical arousal, are subject to much more change than introverts or extroverts depending on context but tend to demonstrate behaviors similar to both extremes (Smith, 1983; Koelega,

1970). We would, therefore, expect ambiverts to demonstrate a sensitivity to environmental influences somewhere between the levels of sensitivity of the two extreme groups.

Current literature demonstrates the importance of temperament and personality in predicting differences in adult mental and physical health. One study by Ahadi and Basharpour (2010) found that highly sensitive or introverted individuals were often more wary of potentially harmful environmental factors and were more susceptible to worry and stress, making them more likely to avoid negative experiences. Extroverts, in contrast, were more open to new experiences and more likely to encounter ACEs and counter-ACEs. Introverts were more likely to experience chronic stress and depression and were less likely than extroverts to seek support or aid in dealing with mental and physical health issues (Lu, 1994; Lincoln, 2008). Because other studies demonstrated significant difference between extroverts and introverts in predicting stress, depression, smoking, and executive functioning, we included these as indicators of adult health.

1.3. The current study

This study builds on other research that demonstrate that childhood experiences affect adult health (e.g., Crandall et al., 2019; Bethell et al., 2019; Narayan et al., 2018) by examining how temperament moderate the relationship between positive and negative childhood experiences with adult health. Current research demonstrates clear differences in how extroverts and introverts interact with their environment. However, little research exists exploring how extroverted/introverted personality temperament affects sensitivity to positive and negative childhood experiences, and how differences in environmental susceptibility affect adult health outcomes. We hypothesized that because of extroverts' tendency to engage with their environment and rely on environmental stimuli, extroverts compared to introverts would demonstrate higher sensitivity to both ACEs and counter-ACEs and adult health. Specifically, for extroverts, high ACEs would have an even greater negative effect on adult health and high counter-ACEs scores would result in better adult health as compared to introverts with similar ACE/counter-ACE scores.

2. Methods

2.1. Procedures

Our sample consisted of 246 adults ages 19–57 who were recruited through Amazon Mechanical Turk (mTurk). MTurk users who were born between 1962 and 2000 were eligible to participate. Participants completed a survey posted on Qualtrics and received \$2.50 for completing the survey. The survey for this study included measures of mental, cognitive, social and physical health as well as temperament, ACEs, and counter-ACEs. This methodology of this study was approved by the Brigham Young University Institutional Review Board, and our procedures have been further described previously (Crandall et al., 2019).

2.2. Measures

2.2.1. Health indicators

Using previously validated measures, all constructs were based on participant self-report. Depression was measured using the Montgomery Asberg Depression Rating Scale (9 items, $\alpha = .86$) (Svanborg and Åsberg, 2001). Participants were presented with statements about depressive symptoms with response options ranging from 1 = never experiencing the symptom, 2 = sometimes experiencing the symptom, 3 = frequently experiencing the symptom, and 4 = always experiencing the symptom. An average score was calculated, with higher scores indicating higher depression.

Stress was measured using the Perceived Stress Scale (10 items, $\alpha = .90$) (Cohen et al., 1994). Participants responded how frequently they

experienced aspects of perceived stress on a five-point Likert scale ranging from 1 (never) and 5 (very often). Sample items included “In the last month, how often have you felt nervous and ‘stressed’?”, and “In the last month how often have you felt that things were going your way?” An average stress score was calculated for each participant, with higher scores indicating higher stress.

Participant executive functioning was measured by the Learning, Executive, and Attention Functioning (LEAF) Scale (30 items, $\alpha = .96$), which includes measures of working memory, attention, and problem-solving (Castellanos et al., 2018). Response options were on a 4-point Likert scale ranging from 1 (never) to 4 (very often). Sample items included “How often do you not listen to others who are teaching or talking to you?” or “How often do you have problems being slow to get started on things?” Average executive functioning scores were calculated, with higher scores indicating better executive functioning.

To measure smoking, participants reported on whether they had ever smoked daily in the past (yes/no) (World Health Organization, 2011).

2.2.2. Temperament, ACEs, and counter-ACEs

Temperament was measured using 12-item extroversion subscale from the Eysenck Personality Inventory (Eysenck and Eysenck, 1992). Responses were dichotomized (1 = yes, 0 = no) and average extroversion score was calculated for each respondent. Scores closer to 1 indicated more extroverted tendencies, and scores closer to 0 indicated more introverted tendencies. The questionnaire included questions such as “Are you a talkative person?” and “are you mostly quiet when you are with other people?”

Self-reported ACEs were measured by the 11-item ACE from the Behavioral Risk Factor Surveillance System Survey (Centers for Disease Control and Prevention, 2016). Responses were dichotomized (1 = yes, 0 = no) and then summed, with scores ranging from 0 to 11 ACEs. Self-reported counter-ACEs were measured by the 10 item Benevolent Childhood Experiences Scale (Narayan et al., 2018). Responses were dichotomized (1 = yes, 0 = no) and summed; scores ranged from 0 to 10 counter-ACEs.

2.3. Data analysis

A series of regression analyses were conducted using childhood experiences and temperament as independent variables and health indicators as dependent variables. Linear regression was conducted for measures of adult stress, depression and EF, and logistic regression for history of smoking. To examine the relationship between childhood experiences and adult health, adjusted regression models were constructed to assess the effect of ACEs, counter-ACEs, and extroversion on each measure of adult health with age and sex as controls. To assess the modifying effect of extroversion, we included an interaction term in the regression models. Next, to better interpret the interaction term, the sample was then stratified into groups based on extroversion scores (Blumenthal, 2001). Those with scores at or below the 25th percentile were labeled “introverts,” scores between the 25th and 75th percentiles were labeled “ambiverts,” and those at or above the 75th percentile were labeled “extroverts.” Two separate stratified adjusted regression models were constructed for each stratum to examine the effect of ACEs and counter-ACEs on adult health. Data were analyzed in SAS version 9.4.

3. Results

3.1. Descriptive statistics

Descriptive data is summarized in Table 1. Briefly, the mean age was 34.60 years (range 19–57 years) and the sample was 42% female. Participants reported a mean score of 8.15 counter-ACEs and 2.67 ACEs. The mean extroversion score was .47 (SD .36) out of 1.

3.2. Extroversion, childhood experiences, and health indicators

Table 2 includes the results from unstratified adjusted regression analyses. Higher extroversion scores were associated with lower stress and depression and higher EF. Extroversion was not associated with smoking. Higher ACE scores were associated with decreases in executive functioning, increased stress, increased depression, and past smoking habits. Higher counter-ACE scores were associated with better higher executive functioning, decreased depression, and decreased stressed.

3.3. Extroversion as a moderator of childhood experiences and health

When the interaction term (extroversion*childhood experience) was added to the model, regression results suggested that extroversion moderated the relationship between ACEs and depression ($b = .08$, $p = .004$), ACEs and executive functioning ($b = -.11$, $p = .003$), counter-ACEs and stress ($b = -.17$, $p = .015$), counter-ACEs and depression ($b = -.10$, $p = .015$), and counter-ACEs and executive functioning ($b = .16$, $p = .001$).

In the stratified models (Table 3), slope estimates for ACEs with depression and with executive functioning were non-significant among introverts but were significant among extroverts, demonstrating that as extroversion scores increased, the positive relationships between ACEs and stress and depression grew in strength and magnitude. Among introverts, the slope estimates for counter-ACEs with stress and depression were relatively low compared to the slope estimates for extroverts, indicating that as extroversion scores increased, the negative relationship between counter-ACEs and stress and depression grew in strength and magnitude. Similarly, as extroversion scores increased, the positive relationship between counter-ACEs and executive functioning grew in strength and magnitude. Results for the ambiverts followed similar trends to extroverts for most health indicators, though slope estimates were generally smaller. In the presence of more ACEs, introverts and ambiverts were at increased odds of having smoked daily in the past, but the results were non-significant for extroverts. Interaction plots for several significant interaction relationship are also included in Figure 1.

4. Discussion

Consistent with DSE theory and our hypothesis, the results suggest that there is a difference in childhood environmental sensitivity based on temperament. For better or for worse, adult participants who self-reported greater extroverted tendencies were generally more sensitive to both adverse and advantageous childhood environmental influences than those participants who reported more introverted tendencies. These results indicate that extroverts fit a more conditional adaptation developmental strategy while alternative adaptation strategies might better describe the development of introverts (Ellis et al., 2011).

One possible explanation for the observed environmental sensitivity in extroverts is the heightened sympathetic nervous response and decreased parasympathetic nervous response extroverts exhibit in response to stress (LeBlanc et al., 2004; Shokri-Kojori et al., 2018). The

Table 1. Descriptive statistics, $N = 246$.

	Mean	SD
% Female	41.87	
Age (years)	34.55	8.77
Counter-ACE (range 0–10)	8.15	2.30
ACE (range 0–11)	2.67	2.67
Extroversion (scale range: 0–1)	0.47	0.36
Stress (scale range: 1–5)	2.52	0.85
Depression (scale range: 1–3)	1.52	0.48
Executive Functioning (scale range 1–4)	3.20	0.57
% Ever Smoked Daily	40.57	

Table 2. Slope estimates and odds ratio for extroversion scores, childhood experiences, and adult health indicators, $N = 246$.

	Stress	Depression	Executive Functioning	Smoking (OR)
Extroversion	-.53***	-.24**	.22*	0.81
ACEs	.06**	.05***	-.05***	1.18**
Counter-ACEs	-.10***	-.05***	.04*	1.04

* $p < .05$, ** $p < .01$, *** $p < .001$. All models control for age and gender.

Table 3. Slope estimates and odds ratios for childhood experiences and adult health, stratified by extroversion scores. $N = 246$.

	Introverts	Ambiverts	Extroverts
Stress			
ACEs	.06	.08*	.14***
Counter-ACEs	-.12**	-.09**	-.30***
Depression			
ACEs	.03	.08***	.09***
Counter-ACEs	-.08***	-.07***	-.16***
Executive Functioning			
ACEs	-.002	-.07***	-.09***
Counter-ACEs	.04	.06**	.15**
Smoking (OR)			
ACEs	1.31*	1.19*	1.12
Counter-ACEs	0.98	0.93	0.65

* $p < .05$, ** $p < .01$, *** $p < .001$. All models control for age and gender.

heightened sympathetic response to stress prompts individuals to engage with their surroundings and seek stimuli in their environment, which presents more opportunities for both positive and negative interactions with other people. Because of extroverts' decreased parasympathetic nervous activation, they may be less able to return to a calm or restful state after a stimulating or stressful event. In extroverts, the dopamine

rush that accompanies positive interactions with others is magnified (Fu, 2013). The heightened sensitivity to dopamine reward in extroverts may encourage more interaction with their environment and causes extroverts to experience a greater sense of elatedness following a positive childhood experience and a greater sense of loss or stress after a negative one.

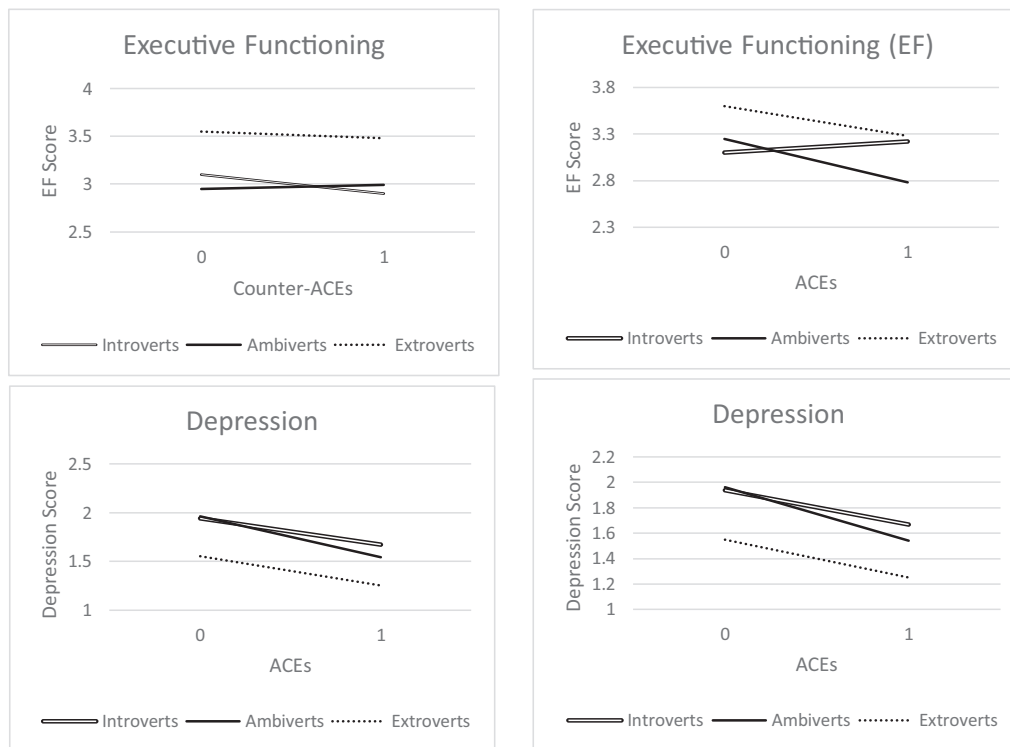


Figure 1. Interaction plots for the relationship between Counter-ACEs and executive function, Counter-ACEs and Stress, ACEs and depression, and ACEs and executive functioning.

The one exception to the trend was related to smoking history. Introverts reported a greater odds of smoking in the face of ACEs. This may be due to their hesitance to look to others for emotional support. For example, some research suggests that introverts are unlikely to seek support from others after stressful life events and are more likely to internalize their pain and turn to alternative methods of self-medication for relief (Swickert et al., 2002; Jacobs and Renandya, 2019). This may also help to explain why extroverts were less likely to smoke after reporting more ACEs: extroverts are more likely to seek emotional support from other people rather than deal with it in an isolated environment.

5. Limitations and future directions

The results of this study should be interpreted according to the following limitations. First, this study was conducted using a convenience sample recruited on Amazon mTurk. Although prior research has found that demographic characteristics of mTurk users are similar to other survey services (Huff and Tingley, 2015; Woods et al., 2015), the representativeness of the results in other populations should be considered carefully. Second, all measures used in the analyses were self-reported and subject to recall bias. Subjects were asked to recall events from their childhood and these events may have been recalled inaccurately. While validated and reliable measures were used to measure all variables, the use of more objective measures would be a valuable next step. Further, some of the described associations may be affected by the fact that extroverts, historically, are more willing to release potentially sensitive personal information than introverts and are typically more self-aware than introverts of existing conditions (Morgan, 2009). To our knowledge, this is the first study that examined how temperament affects the relationship between childhood experiences and adult health. Further research is needed among more diverse populations to understand to what degree these results can be applied to populations with more different cultural backgrounds.

It is important to understand how different temperaments predict how childhood environments affect lifelong health. Greater understanding of how the environment might differentially affect the development of certain children versus others can help parents, teachers, and other adults interacting closely with children to be more conscious of how their interactions with children can affect health throughout life. Thus, the development of modules for teacher continuing education or parent training about childhood experiences, temperament, and health would be advantageous. Additionally, further research is important to understand the relationship between childhood experiences, temperament and lifelong health in larger samples and more diverse populations such as low-income communities. Given the potential physiological differences between introverts and extroverts, future studies might also examine the physiological differences of participants in addition to examining their ACEs, counter-ACEs, temperament, and health.

6. Conclusion

Based on the results of this study, individuals may differ in their sensitivity to both positive and negative childhood experiences based on their level of extroversion. This study adds to existing literature on the Differential Susceptibility to the Environment Theory by providing insight on personality differences that may help distinguish those with the conditional adaptation genotype (e.g., those with greater sensitivity to positive and negative experiences) from those with the alternative. The results of the current study indicated that extroverts had more conditional adaptation compared to introverts and ambiverts except for as it related to smoking. Further studies that examine different health indicators, including health behaviors and diseases, are needed to better understand how temperament affects sensitivity to one's childhood environment. Further research examining key physiological differences

between individuals with extroverted and introverted temperaments may also shed more light on defining characteristics within each group. Increased understanding of how temperament differentially intersects with childhood experiences and the effects on lifelong health would be valuable information for all individuals and programs who work with children.

Declarations

Author contribution statement

Jacob R. Miller: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Aaron Cheung: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Lynne Kirsten Novilla: Analyzed and interpreted the data; Wrote the paper.

AliceAnn Crandall: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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