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Dimensions of temperament and depressive symptoms: Replicating a three-way interaction

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ABSTRACT

High negative emotionality (NE), low positive emotionality (PE), and low self-regulatory capacity (i.e., effortful control or EC) are related to depressive symptoms and furthermore, may moderate one another's relations to such symptoms. Indeed, preliminary evidence suggests they may operate in a three-way interaction (Dinovo & Vasey, 2011), but the replicability of that finding remains unknown. Therefore, we tested this NE × PE × EC interaction in association with depressive symptoms in 5 independent samples. This interaction was significant in 4 of the 5 samples and a combined sample and approached significance in the fifth sample. In contrast, the NE × PE × EC interaction was unrelated to general anxious symptoms and thus may be specific to symptoms of depression. Implications, directions for future research, and limitations are discussed.

1. Introduction

Consideration of temperament/personality factors has brought considerable progress in understanding risk for depression (e.g., Brown, 2007; Klein, Kotov, & Bufferd, 2011). Such research has emphasized two dimensions of emotional/motivational reactivity, typically labeled negative and positive emotionality (NE and PE, respectively; e.g., Carver, Johnson, & Joorman, 2008; Clark, Watson, & Mineka, 1994; Klein, Durbin, & Shankman, 2009), and, more recently, one self-regulatory dimension labeled effortful control (EC; Beevers, 2005; Carver et al., 2008; Muris & Ollendick, 2005). NE can be conceptualized as the overarching emotional and motivational dimension underlying constructs such as negative affectivity (NA; Clark & Watson, 1991), neuroticism (N; Eysenck, 1967), and behavioral inhibition system (BIS) sensitivity (Corr, 2002; Gray, 1970). Common to these constructs is the tendency to experience displeasurable engagement with oneself and the world as reflected by negative emotions (e.g., distress and sadness) and avoidance motivation (Carver et al., 2008; Depue & Lenzenweger, 2005). PE can be conceptualized as the overarching emotional and motivational dimension underlying constructs such as positive affectivity (PA; Clark & Watson, 1991), extraversion (E; Eysenck, 1967), and behavioral activation system (BAS) sensitivity (Corr, 2002; Gray, 1970). Common to these constructs is the tendency to experience pleasurable engagement with oneself and the world as reflected by positive emotions (e.g., happiness and enthusiasm), sociability, and approach motivation (Carver et al., 2008; Depue & Lenzenweger, 2005). Finally, EC is conceptualized as the capacity to override such reactive responses and substitute responses in service of long-term goals (Rothbart & Rueda, 2005). Thus, it reflects the capacity for executive control of cognition and behavior, including the ability to focus, shift, and sustain attention (i.e., attention control), inhibit inappropriate responses (i.e., inhibitory control), and initiate approach responses despite reactive motivation to avoid or a lack of approach motivation (i.e., activation control). EC overlaps with the Big Five personality dimension of conscientiousness in that both capture individual differences in attentional and behavioral control (e.g., Jensen-Campbell et al., 2002). Individuals high in conscientiousness are described as well organized, planful, persistent, goal-oriented, and able to delay gratification (Tackett & Krueger, 2005).

High levels of NE are strongly associated with both depressive and anxious symptoms whereas low levels of PE are predominantly associated with depressive symptoms (Clark & Watson, 1991). These associations are seen concurrently and prospectively in children, adolescents, and adults (for reviews see Anderson & Hope, 2008; Clark et al., 1994; De Pauw & Mervielde, 2010; Klein et al., 2011). Although fewer studies have considered EC, those

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doing so have generally found low levels of EC to be associated with depressive and internalizing symptoms (see Carver et al., 2008). This is true concurrently for both types of symptoms (e.g., Loukas & Roalson, 2006; Muris, 2006; Verstraeten, Vasey, Raes, & Bijttebier, 2009; Yap et al., 2011) and prospectively for internalizing symptoms (Lemery-Chalfant, Doelger, & Goldsmith, 2008; Oldehinkel, Hartman, Ferdinand, Verhulst, & Ormel, 2007). However, studies to date have failed to find prospective evidence in the case of depressive symptoms (Loukas & Roalson, 2006; Verstraeten et al., 2009). Similarly, research has shown that low conscientiousness is consistently associated with concurrent Major Depressive Disorder as well as depressive symptoms (see Kotov, Gamez, Schmidt, & Watson, 2010) but prospective studies of this link are lacking (Klein et al., 2011).

Whereas past research has typically considered only the additive associations of NE, PE, and EC with depressive symptoms, these dimensions have considerable potential to moderate one another's association with symptoms (e.g., see Carver et al., 2008; Depue & Lenzenweger, 2005; Derryberry & Tucker, 2006; Klein et al., 2009; Muris & Ollendick, 2005). For example, despite the robust evidence linking high levels of NE to depressive symptoms, not all individuals with high NE experience depressive symptoms and emerging theory and research suggest that PE moderates this link (Klein et al., 2011). Such an effect is consistent with findings that positive emotions can buffer against the deleterious effects of negative emotionality (e.g., Tugade & Fredrickson, 2004).

Although most studies relating NE and PE to depression have not reported testing the NE × PE interaction, those doing so have typically found it to be significant. For example, Joiner and Lonigan (2000) found that PA moderated NA's association with diagnostic status concurrently and with symptom change over time in two psychiatric inpatient samples. The pattern of this interaction was such that NA was significantly associated with a concurrent diagnosis of depression and an increase in depressive symptoms across two months when PA was low but not when it was high. This interaction has been replicated in non-clinical youth samples both cross-sectionally (Loney, Lima, & Butler, 2006) and prospectively (Vasey, Harbaugh, Mikolich, Firestone, & Bijttebier, 2013; Wetter & Hankin, 2009). Similar results have been found in tests of the analogous interactions involving N, E, BIS, and BAS in youth and adult samples (Gershuny & Sher, 1998; Hotard, McFatter, McWhirter, & Stegall, 1989; Knyazev & Wilson, 2004; McFatter, 1994; Pavot, Diener, & Fujita, 1990). Although some studies have not found such interactions (e.g., Jorm et al., 2000; Verstraeten et al., 2009), the weight of the evidence indicates that PE moderates the association between NE and depressive symptoms.

There is also clear reason to consider EC as a moderator of NE's association with depressive symptoms (e.g., see Beevers, 2005; Carver et al., 2008; Derryberry & Tucker, 2006; Klein et al., 2011; Muris & Ollendick, 2005; Rothbart, Ahadi, & Hershey, 1994). For example, Lonigan and Phillips (2001) proposed an interactive temperament model of risk for distress related disorders, which asserts that an individual with a high level of NE may experience less distress than high NE peers if s/he has a high enough level of EC to override NE-driven responses (e.g., the tendency to ruminate). Although that model was focused primarily on anxiety symptoms, the authors also noted its relevance for understanding NE-related risk for depressive symptoms. Supporting this, studies in youth samples have demonstrated that EC moderates the relation between NE and concurrent internalizing (e.g., Muris, 2006; Muris, Meesters, & Blijlevens, 2007; Oldehinkel et al., 2007) and depressive symptoms (e.g., Verstraeten et al., 2009; Yap et al., 2011). As expected, high NE predicts greater symptoms when EC is low versus high. Prospective studies, however, have produced less consistent results. Specifically, studies by Loukas and Roalson (2006) and Verstraeten et al. (2009) failed to find an NA × EC interaction predicting future internalizing and depressive symptoms respectively, whereas Vasey et al. (2013) found that NA was related to change in depressed mood across one month only when EC was low.

There is also reason to expect that PE and EC should interact in relation to depressive symptoms (Anthony, Lonigan, Hooe, & Phillips, 2002; Rothbart et al., 1994). Carver et al. (2008) noted, "Effortful control sometimes means forcing the production of an action that one does not want to take (overriding a reflexive tendency toward *inaction*). For example, effortful control can lead a sedentary adult to exercise, or can lead a person to stay engaged in a boring task. . ." (p. 915). Thus, high levels of EC might allow an individual with low PE to increase contact with rewards from the environment and thereby avoid becoming or staying depressed (Dinovo & Vasey, 2011). Unfortunately, few studies have tested this interaction in relation to depressive symptoms. Two studies of youth samples have reported the expected interaction in relation to concurrent depressive symptoms (Vasey et al., 2002 [as cited in Lonigan, Vasey, Phillips, & Hazen, 2004, pp. 15–16]; Verstraeten et al., 2009) whereas two other studies have failed to find it (de Boo & Kolk, 2007; Miller et al., 2009). Also, Verstraeten et al. (2009) failed to find it prospectively.

In sum, despite good reasons to expect EC to moderate the NE- and PE-depression links, evidence for the NE × EC and PE × EC interactions is sparse and mixed. The mixed results may reflect the fact that power to detect significant interactions in typical (i.e., unselected) samples is notoriously low (see McClelland & Judd, 1993). However, evidence showing that NE and PE themselves interact in relation to such symptoms suggests another possibility: that the effects of each of these 2-way interactions may be moderated by a third dimension (i.e., the NE × EC interaction may be conditional upon levels of PE and the PE × EC interaction may be conditional upon level of NE). If so, unless these 2-way interactions are strongest at average levels of the third variable, they are unlikely to achieve significance in typical samples.

Assuming the 3-way interaction is replicable, characterizing the conditional 2-way interactions is important because their implications vary depending on their pattern. For example, if the NE × EC interaction were strongest when PE is low, it could imply that low EC strengthens the link between high NE and depressive symptoms when PE is low but has little effect when PE is high. Such a pattern might suggest that being deficient in the capacity to control or behave counter to one's strong NE-mediated motivation to avoid or withdraw matters most when reactive motivation supporting approach responses is lacking due to low PE. Similarly, if the PE × EC interaction were strongest when NE is high, it could imply that being deficient in the capacity to initiate effortful approach responses given a lack of reactive approach motivation matters most when one's displeasurable engagement with the world is strong and thus encourages avoidance or withdrawal. Alternatively, if the NE × EC interaction were strongest when PE is high, it could imply that the combination of high NE and low PE is much harder to overcome effortfully than is high NE alone. Put another way, it could imply that it is easier to initiate effortful approach responses despite strong displeasurable engagement with the environment when one is also reactively motivated to seek pleasurable engagement. Similarly, if the PE × EC interaction were stronger when NE is low versus high it could imply that the combination of low PE and high NE is more difficult to overcome effortfully than is low PE alone.

Consistent with this view, Dinovo and Vasey (2011) found evidence for a NE × PE × EC interaction in relation to depressive symptoms as measured by the Mood and Anxiety Symptom Questionnaire (MASQ; Watson et al., 1995). Specifically, a BIS × BAS × EC interaction was significant in predicting symptoms of general distress (i.e., those symptoms common to both depression and anxiety including feeling sad, worried and hopeless). Con-

sidered as conditional 2-way interactions, a BIS × BAS interaction was seen when EC was either low or high, a BIS × EC interaction was seen only when BAS was average or higher, and a BAS × EC interaction was seen only when BIS was low. Similarly, Dinovo and Vasey (2011) found a BIS × BAS × EC interaction for symptoms of anhedonia, albeit only among males.[1] A BIS × BAS interaction emerged when EC was average or above, whereas a BIS × EC interaction emerged only when BAS was low and a BAS × EC interaction emerged only when BIS was high.

To our knowledge, there have been no other attempts to test the NE × PE × EC interaction in adults and it has not been tested in a youth sample. Therefore, we tested the replicability of this interaction in a series of five independent samples of children, adolescents and young adults (ages 9–20 years). Because Dinovo and Vasey (2011) found somewhat different patterns of results for symptoms of general distress and anhedonia, we also sought to clarify the extent to which the 3-way interaction is specific to depressive symptoms or extends also to symptoms of anxiety. Despite much overlap between depressive and anxious symptoms in youth, these symptoms can be distinguished (e.g., Crowley & Emerson, 1996) and understanding these different symptom sets is important for understanding the development of psychopathology (Anderson & Hope, 2008). We expect that the NE × PE × EC interaction is most relevant to depressive symptoms compared to symptoms of general or global anxiety given that PE is involved in depressive but not anxious symptoms (Brown, Chorpita, & Barlow, 1998; Mineka, Watson, & Clark, 1998).

In summary, the present study tested two specific hypotheses: (1) the NE × PE × EC interaction will be significantly associated with concurrent depressive symptoms; (2) the NE × PE × EC interaction will be associated with depressive but not anxious symptoms. The first hypothesis was tested in 5 independent samples spanning the age range from childhood to late adolescence. A measure of anxious symptoms was available in four of those samples, thus permitting four tests of the second hypothesis.

2. Material and methods

2.1. Participants

Sample 1. Sample 1 comprised 332 children and adolescents (56.7% female) from the Denver, Colorado area, ranging in age from 9 to 15 years (M_{age} = 12.0 years, *SD* = 2.4). The sample was 67.5% Caucasian, with the remainder being 7.1% African American, 6.3% Latino/Hispanic, 3.5% Asian or Pacific Islander, and 14.2% bi- or multi-racial (see Barrocas, Hankin, Young, & Abela, 2012; Hankin, Jenness, Abela, & Smolen, 2011 for additional details).

Sample 2. Sample 2 comprised 448 children (44.3% female) from the Tallahassee, Florida area, ranging in age from 11 to 18 years (M_{age} = 14.3 years, *SD* = 1.8). The sample was 63.5% Caucasian, 21.4% African American, 6.0% Latino/Hispanic, 2.4% Asian or Pacific Islander, and 3% other (4% did not indicate ethnicity).

Sample 3. Sample 3 comprised 598 children (50.7% female) from the Tallahassee, Florida area, ranging in age from 9 to 18 years (M_{age} = 14.2 years, *SD* = 2.2). The sample was 64% Caucasian, 23.1% African American, 7.4% Latino/Hispanic, 2.9% Asian or Pacific Islander, and 2.6% other.

Sample 4. Sample 4 comprised 210 children (40.4% female) from central Ohio, ranging in age from 11 to 15 years (M_{age} = 12.9 years, *SD* = 0.9). The sample was predominantly Caucasian (89.4%), with the remainder being 1.0% African American/Black, 0.5% Latino/Latina/Hispanic, 1.9% Asian or Pacific Islander, and 6.3% bi- or multiracial.

Sample 5. Sample 5 comprised 309 adolescents and young adults (37.9% female) from the vicinity of Leuven, Belgium, ranging in age from 13 to 20 years (M_{age} = 16.3 years, *SD* = 1.3). The sample's ethnicity was predominantly Caucasian (94%).

2.2. Measures

To conserve space, measures used across samples are described below by construct, with the sample(s) using each noted.

2.2.1. NE and PE measures

Positive and Negative Affectivity Schedule (PANAS) – Trait Version – (Watson, Clark, & Tellegen, 1988). The PANAS is a self-report instrument designed to measure stable individual differences in affectivity. It consists of two 10-item subscales that assess negative affectivity (NA) and positive affectivity (PA). Evidence supports the reliability and validity of the PANAS when used with children and adolescents (e.g., Lonigan, Phillips, & Hooe, 2003). A general time frame (i.e., participants were asked to rate items for how they "usually feel") was used to assess children's trait affectivity. The PANAS was used in Samples 2–4. Internal consistency was adequate in all cases (Cronbach's alphas: NA ⩾ .77; PA ⩾ .76).

PANAS-C (Laurent et al., 1999). The PANAS-C is a self-report measure of positive and negative affectivity. The PANAS contains 27 items consisting of emotions (e.g. "interested" or "sad") and participants rate the extent to which they have experienced each particular emotion on a five-point Likert scale ranging from "Very slightly or not at all" (1) to "Extremely" (5) during the past few weeks. The PANAS-C yields a 12-item PA scale and a 15-item NA scale. These scales have adequate reliability and validity (Crawford & Henry, 2004). The PANAS-C was used in Sample 1. Internal consistency was adequate (alphas: NA = .89; PA = .84).

Adult Temperament Questionnaire-Short Form (ATQ-Short; Rothbart, Ahadi, & Evans, 2000) is a 77-item self-report measure of adult temperament. Participants rate the items based on how well they think each item describes them using a 1 ("extremely untrue") to 7 ("extremely true") Likert scale. For the present study NE was represented by the sum of the items on the Sadness scale (measuring negative affect and lower mood and energy related to suffering, disappointment, and loss) and the Fear scale (measuring negative affect related to the anticipation of distress). PE was represented by the sum of the items on the Positive Affect scale (measuring frequency, duration, and intensity of positive emotional experiences) and the Sociability scale (measuring the degree of pleasure derived from social interactions). These scales were used in Sample 5.[2] Internal consistency was adequate (alphas: NE = .80; PE = .68).

2.2.2. EC measures

[1] Among females, rather than the 3-way interaction, significant BIS × EC and BAS × EC interactions were found. High BIS and low BAS were associated with elevated symptoms of anhedonia, but only when EC was low. In other words, among females the BIS × EC was significant at average levels of BAS and the BAS × EC interaction was significant at average levels of BIS and neither varied significantly in magnitude across levels of the third variable.

[2] In constructing these NE and PE scores, we chose to omit several subscales based on their item content and findings in other samples raising doubts about their relevance to the broader constructs. Specifically, from the PE score we omitted the High Intensity Pleasure subscale, which pertains to enjoyment of intense stimuli (e.g., flashing lights and loud music). In the NE score we chose not to include the Discomfort and Frustration subscales. The former pertains to discomfort triggered by sensory stimuli such as bright lights or loud music whereas the latter's items primarily pertain to delay-induced annoyance. In past samples we have found the High Intensity Pleasure subscale to be only weakly correlated with PA as measured by the trait PANAS. Similarly, we have found Discomfort and Frustration to be more weakly correlated with PANAS NA than the Fear and Sadness subscales. Nevertheless, we also tested a model in which these subscales were included and the results were unchanged. That analysis is reported in the online supplement.

Effortful Control Scale (ECS; Lonigan & Phillips, 2002). The ECS consists of 24 self-report items that are rated on a 5-point scale with regard to how much each item describes the individual "most of the time." Half of the items tap Persistence/Low Distractibility (P/LD) with the remaining items tapping Impulsivity. This two-factor structure has been supported by confirmatory factor analysis (Verstraeten, Vasey, Claes, & Bijttebier, 2010). We used the ECS-P/LD scale because it taps the aspects of EC most relevant to depressive and anxious symptoms (i.e., attentional control and activation control). Consistent with this view, Verstraeten et al. (2010) compared five self-report scales measuring aspects of EC and found the ECS-P/LD scale was the most strongly associated with self-reports of depressive symptoms. They also found it to be strongly correlated with broadband measures of EC from self- and parent-reports on the Early Adolescent Temperament Questionnaire (Capaldi & Rothbart, 1992). Past studies have found the ECS-P/LD scale to have excellent internal consistency. The ECS-P/LD scale was used in Samples 2–4. Internal consistency was adequate in all cases (alpha $\geqslant$ .82).

Early Adolescent Temperament Questionnaire – Revised (EATQ-R; Capaldi & Rothbart, 1992). The EATQ-R is a 65-item self-report measure of temperament in children and adolescents. Only the 16 items comprising the broadband EC scale were considered in this study. Each item is rated on a five-point scale ranging from "Almost always untrue" (1) to "Almost always true" (5). The EATQ-R EC scale has good psychometric properties, including acceptable internal consistency and good test–retest reliability in non-clinical youth (Muris & Meesters, 2009). It was used in Sample 1 and had adequate internal consistency (alpha = .74).

Adult Temperament Questionnaire-Short Form (ATQ-Short; Rothbart et al., 2000). EC was represented by the sum of the items on the Attentional Control, Activation Control, and Inhibitory Control scales. The ATQ-EC Scale was used in Sample 5 (alpha = .74).

2.2.3. Symptom measures

Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996). The BDI-II is a 21-item questionnaire tapping cognitive, affective, and somatic depressive symptoms. Items are rated on a four-point scale, yielding a total score ranging from 0 to 63. The BDI-II has good reliability and validity (e.g., Beck et al., 1996). It was used in Sample 5 (alpha = .90).

Children's Depression Inventory (CDI; Kovacs, 1992). The CDI is a 27-item self-report measure of depressive symptoms. Kovacs (1980/1981) reported adequate internal consistency and 1-month test–retest reliabilities and the scale correlates with clinician-rated depression (e.g., r = .55; Kovacs, 1992). The CDI was used in Samples 1–4 and had adequate internal consistency in all cases (alpha $\geqslant$ .82).

Multidimensional Anxiety Scale for Children (MASC; March, Parker, Sullivan, Stallings, & Conners, 1997). The MASC is a widely used self-report measure of anxious symptoms in children and adolescents. The MASC contains 39 items that assesses physical symptoms of anxiety, harm avoidance, social anxiety, and separation anxiety. Each item presents a symptom of anxiety (e.g. "gets scared when parents go away" or "worries about getting called on in class), and participants indicate how true each item is for them on a four-point Likert scale ranging from "Never true" (0) to "Very true" (3). A total score, ranging from 0 to 117, is generated by summing all items, with a higher score indicating higher levels of anxious symptoms. The MASC has high internal consistency (Muris, Merckelbach, Ollendick, King, & Bogie, 2002) and test–retest reliability (March et al., 1997). The MASC was used in Sample 1 (alpha = .89).

Revised Children's Anxiety and Depression Scale (RCADS; Chorpita, Yim, Moffitt, Umemoto, & Francis, 2000). The RCADS is a 47-item measure designed to assess symptoms of anxiety disorders (i.e., social phobia, panic disorder, separation anxiety disorder, generalized anxiety disorder, obsessive compulsive disorder) and major depressive disorder. Participants rate items on a 4-point scale from 0 ("never") to 3 ("always") to indicate the frequency of symptoms. A total anxiety score (37 items) and a depression score (10 items) can be derived. Previous research has indicated that the RCADS is a reliable and valid measure of childhood anxiety and depressive symptoms (e.g., Chorpita et al., 2000). The RCADS was used in Sample 2 (alphas: depression scale = .82; anxiety scale = .93).

Revised Children's Manifest Anxiety Scale (RCMAS; Reynolds & Richmond, 1985). The RCMAS is a 37-item self-report measure of general anxiety. It consists of 28 anxiety items and 9 social desirability (i.e., "lie scale") items. Studies have demonstrated that the RCMAS has good internal consistency and concurrent validity (Reynolds & Richmond, 1985). The RCMAS was used in Samples 2–4. In Sample 3, items were scored dichotomously (i.e., True–False) as in the original version of the RCMAS, yielding a total score ranging from 0 to 28. However, in Samples 2 and 4, items were instead scored on a 4-point Likert scale ranging from "Never" to "Always", yielding a score ranging from 0 to 112. In all three samples, internal consistency was adequate (alpha $\geqslant$ .89).

2.3. Procedure

Procedures followed for each sample were approved by the Institutional Review Board (IRB) of the relevant university. In all cases participants were recruited through letters describing the study in question, which were sent home with potential participants. In Samples 1–4 consent forms were also included. In those samples, potential participants receiving parental consent and who assented to participate were included in the study. In Sample 5, potential participants and their parents were informed about the aim of the study and were invited to take part. A passive informed consent was used, because research has shown that active informed consent results in lower participation rates and bias in prevalence of risk behavior, such as substance use, which was the main research topic of the study for which Sample 5 was collected (Frissell et al., 2004). Participants in Sample 5 were all adolescents for whom a form requesting exclusion from the study was not returned.

Questionnaires were administered in a group format in Samples 2, 3, and 5, whereas they were administered individually during a home (Sample 4) or lab (Sample 1) visit. In all cases, the questionnaires were embedded within a larger battery of tests. Also in all cases, research assistants were present to provide instructions and answer questions.

3. Results and discussion

3.1. Data analytic strategy

All regression analyses were conducted hierarchically, with Sex, Age, NE, PE, and EC entered in Step 1, the NE $\times$ PE, NE $\times$ EC and PE $\times$ EC product terms entered in Step 2, and the NE $\times$ PE $\times$ EC product term entered in Step 3. To ease interpretation, all variables were standardized prior to computing the interaction terms. Regression diagnostics were examined for each analysis to determine if extreme data points were present that might be exerting excessive influence on overall model fit or on individual beta weights. Specifically, we examined DFFITS and DFBETA values using ±1.0 as a cutoff, as well as the Studentized deleted residual (SDR) for each case (Cohen, Cohen, West, & Aiken, 2003). Results of these diagnostics are described for each model. All interactions were interpreted using PROCESS, which is an SPSS utility for conditional process modeling (see Hayes, 2013). Specifically, the 3-way

Table 1
Descriptive statistics for each sample.

Variable	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Age	14.3 (1.7)	14.2 (2.2)	12.9 (0.9)		16.4 (1.3)
PANAS NA	19.0 (6.0)	18.9 (5.7)	16.6 (5.4)	–	–
PANAS PA	34.7 (6.6)	335.0 (6.6)	37.8 (5.6)	–	–
PANAS-C NA	–	–	–	28.3 (9.7)	–
PANAS-C PA	–	–	–	44.3 (8.2)	–
ECS P/LD	46.4 (7.2)	44.1 (8.5)	44.8 (7.8)	–	–
EATQ-R EC	–	–		55.3 (8.3)	–
ATQ fear	–	–	–	–	3.3[c] (0.9)
ATQ sadness	–	–	–	–	3.8[c] (1.1)
ATQ positive affect	–	–	–	–	4.8[c] (0.9)
ATQ sociability	–	–	–	–	5.2[c] (1.1)
ATQ EC	–	–	–	–	4.0[c] (0.7)
CDI	8.5 (7.1)	8.7 (7.3)	5.9 (5.4)	6.6 (5.4)	–
RCADS	6.3 (4.4)				–
BDI	–	–	–	–	9.8 (8.6)
RCMAS	25.7[a] (13.0)	7.6[b] (5.9)	28.7[a] (10.6)	–	–
RCADS anxiety total	22.2 (12.9)	–	–	–	–
MASC total	–	–	–	41.0 (15.7)	–

[a] RCMAS score reflects 0–3 Likert scale rather than the original dichotomous scale for each item.
[b] RCMAS score reflects the original dichotomous response scale.
[c] ATQ scores reflect average scores per item rather than scale totals.

interaction was interpreted by examining regions of significance for each of the 2-way interactions. Using PROCESS we conducted bootstrapped (5000 resamples) tests of each 2-way interaction at all levels of the third variable. We also tested simple slopes for each variable's association with symptoms at the four combinations of high (90th percentile) and low (10th percentile) levels of the second and third variables (e.g., we tested NE's slope at the four combinations of high and low PE and EC). For each family of four simple slope tests, we used a Bonferroni-adjusted alpha of .0125. Alpha for all other tests was .05.

3.2. Descriptive statistics

Means and standard deviations for all variables in each sample are shown in Table 1.

3.3. Primary analyses

3.3.1. Sample 1

CDI. Preliminary analyses revealed four cases with high influence on model fit (DFFITS > |1.08|). With those cases in the model the NE × PE × EC interaction was significant ($sr = -.14$, $p < .001$) and, as shown in Table 5, it remained significant when they were deleted ($sr = -.12$, $p = .002$). Significant effects were also found for NE, PE, and EC as well as the NE × PE interaction.

PROCESS revealed that the NE × PE interaction was significantly negative for EC > −.94 SDs. Fig. 1a depicts this interaction by showing simple slopes representing NE's association with CDI at the four combinations of high and low levels of PE and EC. As shown in Fig. 1a, at high EC (dashed lines), NE was significantly associated with symptoms when PE was low (black line, simple slope (B) = .85, $p < .001$) but not high (grey line; $B = .06$, $p = .53$). In contrast, at low EC (solid lines), NE was significantly associated with symptoms when PE was high (grey line; $B = .38$, $p < .001$) and low (black line; $B = .50$, $p < .001$). The NE × EC interaction was significantly negative for PE > .73 SDs and significantly positive for PE < −1.21 SDs. These conditional interactions are also apparent in Fig. 1a. The pattern of the negative interaction at high PE (grey lines) was such that NE was significantly associated with symptoms when EC was low (solid line; $B = .38$, $p < .001$) but not when it was high (dashed line; $B = .06$, $p = .53$). In contrast, the pattern of the positive interaction at low PE (black lines) was such that NE was more strongly associated with symptoms when EC was high (dashed line; $B = .85$, $p < .001$) versus low (solid line; $B = .50$, $p < .001$). Finally, the PE × EC interaction was significantly positive for NE < −.55 SDs and significantly negative for NE > 1.46 SDs. These conditional patterns are depicted in Fig. 1b, which shows PE's association with symptoms at high and low levels of NE and EC and in Fig. 1c, which depicts EC's association with symptoms at high and low levels of NE and PE. As shown in Fig. 1b, the positive interaction pattern at low NE (grey lines) was such that PE's correlation with symptoms was significant when EC was low (solid line; $B = -.37$, $p < .001$) but not high (dashed line; $B = .03$, $p = .69$). In contrast, the negative interaction pattern at high NE (black lines) was such that PE was more strongly associated with symptoms when EC was high (dashed line; $B = -.77$, $p < .001$) versus low (solid line; $B = -.46$, $p < .001$). Similarly, as shown in Fig. 1c, when NE was high (solid lines), EC's correlation with symptoms was significant when PE was high (grey line; $B = -.42$, $p < .001$) but not low (black line; $B = -.12$, $p = .36$). In contrast, when NE was low (dashed lines), EC was significantly associated with symptoms when PE was low (black line; $B = -.46$, $p < .001$) but not high (grey line; $B = -.10$, $p = .21$).

MASC. Preliminary analyses revealed two cases with high influence on model fit (DFFITS > |1.00|). With those cases included, the NE × PE × EC interaction was not significant ($sr = -.069$, $p = .14$) and, as shown in Table 5, it remained non-significant when those cases were deleted ($sr = -.058$, $p = .204$). The only terms reaching significance were those for Sex and NE.

3.3.2. Sample 2

Depression. Because the CDI and RCADS-MDD scores were strongly correlated (r = .75, $p < .001$), to reduce the number of tests conducted they were standardized and averaged to create a composite depression score, which served as the dependent variable (DV).[3] Preliminary analyses revealed a single case with high influence on model fit (DFFITS = −1.14). With that case included the NE × PE × EC interaction was significant ($sr = -.08$, $p = .02$) and, as shown in Table 2, it remained significant when that case was deleted ($sr = -.09$, $p = .009$). Effects were also found for the NE, PE, and EC main effects as well as the NE × PE and NE × EC interactions.

[3] The separate analyses for the RCADS and CDI can be found in the online supplemental material.

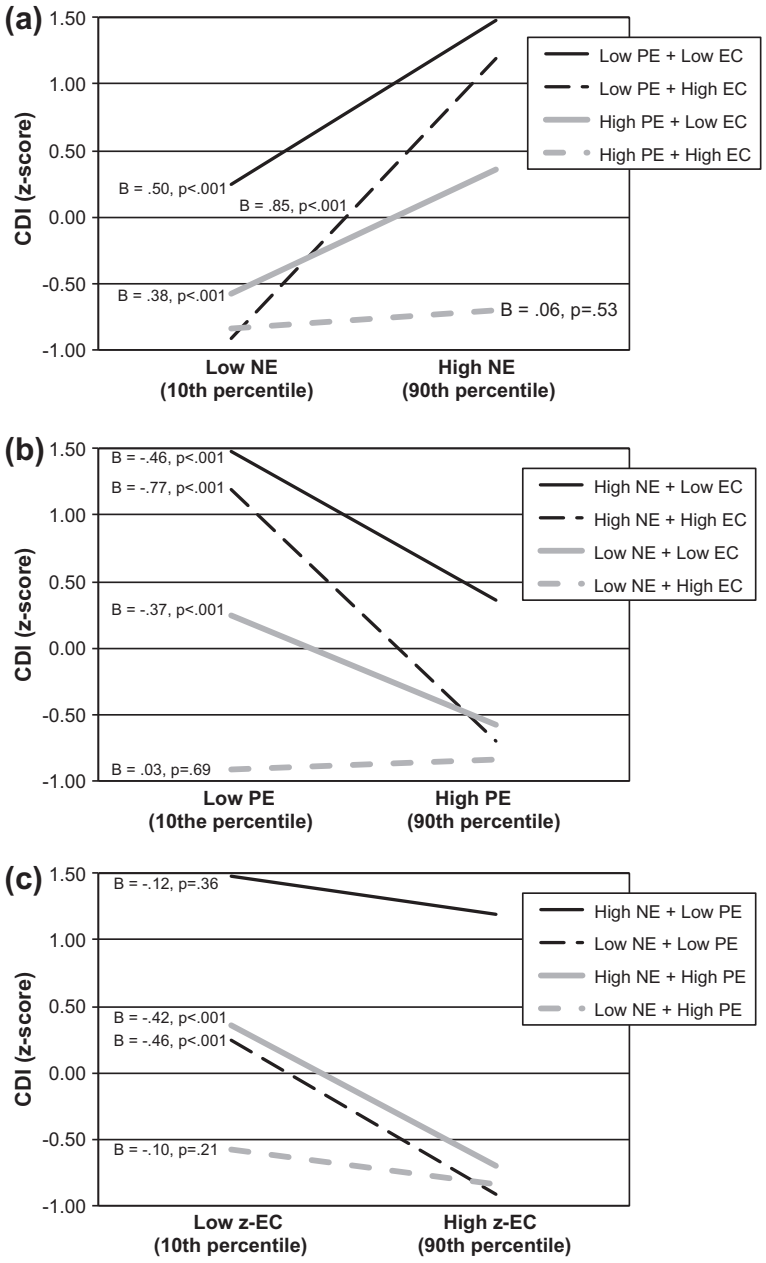

Fig. 1. Conditional 2-way interaction patterns in Sample 1. (a) NE predicting depressive symptoms at combinations of high and low PE and EC. (b) PE predicting depressive symptoms at combinations of high and low NE and EC. (c) EC predicting depressive symptoms at combinations of high and low NE and PE.

PROCESS revealed that the NE × PE interaction was significantly negative for EC > −.29 SDs. Because the pattern was very similar to that seen in Sample 1 (see Fig. 1a, dashed lines), to conserve space it is not depicted graphically.[4] At high EC, NE was significantly associated with symptoms when PE was low ($B = .52$, $p < .001$) but not high ($B = .05$, $p = .58$). However, when EC was low, NE's association was the same when PE was high ($B = .50$, $p < .001$) and low ($B = .50$, $p < .001$). The NE × EC interaction was significantly negative for PE > −.34 SDs and its pattern was similar to the negative pattern seen at high PE in Sample 1 (see Fig. 1a, grey lines). When PE was high, NE was significantly associated with symptoms when EC was low ($B = .50$, $p < .001$) but not high ($B = .05$, $p = .58$). In contrast, when PE was low, NE was significantly associated with symptoms when EC was high ($B = .50$, $p < .001$) and low ($B = .50$, $p < .001$). Finally, the PE × EC interaction was significantly negative for NE > 1.28 SDs and its pattern was similar to the negative interaction seen at high NE in Sample 1 (see Fig. 1b, black lines). At high NE, PE's association with symptoms was stronger when EC was high ($B = -.47$, $p < .001$) versus low ($B = -.22$, $p < .001$). In contrast, at low NE, PE was not significantly associated with symptoms when EC was low ($B = -.23$, $p = .032$ [recall that alpha was set at .0125 for tests of simple slopes]) or high ($B = -.05$, $p = .47$). Similarly, at high NE, as in the negative pattern in Sample 1 (see Fig. 1c, solid lines) EC's association with symptoms was stronger when PE was high ($B = -.55$, $p < .001$) versus low ($B = -.30$, $p < .001$). However, at low NE, EC was associated with symptoms when PE was low ($B = -.32$, $p < .001$) but not high ($B = -.15$, $p = .10$). This follows the positive interaction pattern seen in Sample 1 (see Fig. 1c, dashed lines), although that form of the interaction did not reach significance in this sample.

[4] The graphs for Sample 2 can be found in the online Supplemental material.

Table 2
Sample 1 regression analyses.

Step/variables added	CDI				MASC			
	R^2	ΔR^2	*B* (*SE*) at final step	*sr* at final step	R^2	ΔR^2	*B* (*SE*) at final step	*sr* at final step
Step 1	.480***				.322***			
Constant			−.01 (.04)				−.14 (.08)	
Sex			.02 (.04)	.03			.30** (.10)	.14**
Age			.02 (.04)	.02			−.14** (.05)	−.14**
NE			.44*** (.04)	.41***			.49*** (.05)	.42***
PE			−.37*** (.04)	−.36***			.07 (.05)	.06
EC			−.27*** (.04)	−.26***			−.04 (.05)	−.04
Step 2	.517***	.037***			.329***	.007		
NE × PE			−.18*** (.04)	−.19***			−.09† (.05)	−.08†
NE × EC			.00 (.04)	.00			.02 (.05)	.02
PE × EC			.02 (.04)	.02			−.09† (.05)	−.08†
Step 3	.532***	.015**			.332***	.003		
NE × PE × EC			−.11** (.04)	−.12**			−.05 (.04)	−.06

Note: *n* = 328 for CDI and *n* = 330 for MASC; NE = trait PANAS-C NA scale, PE = trait PANAS-C PA, EC = EATQ-R EC scale; all main effect variables were standardized; *sr* = semi-partial correlation coefficient.
* $p < .05$.
† $p < .10$.
** $p < .01$.
*** $p < .001$.

Table 3
Sample 2 regression analyses.

Step/variables added	Depression composite				RCMAS			
	R^2	ΔR^2	*B* (*SE*) at final step	*sr* at final step	R^2	ΔR^2	*B* (*SE*) at final step	*sr* at final step
Step 1	.473***				.326***			
Constant			−.03 (.04)				−.03 (.06)	
Sex			−.02 (.03)	−.02			.18 (.08)	.09
Age			−.01 (.04)	−.01			−.15*** (.04)	−.15***
NE			.37*** (.04)	.32***			.33*** (.05)	.28***
PE			−.24*** (.04)	−.21***			−.07 (.04)	−.06
EC			−.33*** (.04)	−.28***			−.36*** (.04)	−.31***
Step 2	.491***	.018**			.332***	.007		
NE × PE			−.10* (.04)	−.08*			−.03 (.05)	−.03
NE × EC			−.08** (.03)	−.10**			.06 (.04)	.05
PE × EC			−.01 (.04)	.00			−.08 (.05)	−.06
Step 3	.499***	.008**			.333***	.000		
NE × PE × EC			−.07** (.03)	−.09**			.02 (.04)	.02

Note: *n* = 447; depression composite = average of the standardized CDI and RCADS-MDD scales; NE = trait PANAS NA scale, PE = trait PANAS PA, EC = ECS-P/LD scale; all main effect variables were standardized; *sr* = semi-partial correlation coefficient.
† $p < .10$.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Anxiety. Because the RCMAS and RCADS-Anxiety scores were strongly correlated (r = .78, $p < .001$), they were standardized and averaged to create a composite anxiety score, which served as the DV. The initial regression analysis revealed a single case with high influence on model fit (DFFITS = 1.18). With that case in the model the NE × PE × EC interaction was not significant (*sr* = −.001, $p = .976$) and, as shown in Table 2, it remained non-significant when the case was deleted (*sr* = .02, $p = .69$). Only the main effects of age, NE, and EC were significant.

3.3.3. Sample 3

CDI. Preliminary analyses revealed a single case with high influence on model fit (DFFITS = 1.57, SDR = 4.14). With that case included, the NE × PE × EC interaction was not significant (*sr* = −.04, $p = .228$). However, as shown in Table 3, when that case was dropped, that interaction approached significance (*sr* = −.061, $p = .056$). Significant terms were also found for the NE, PE, and EC main effects as well as the NE × PE interaction.

PROCESS revealed that the NE × PE interaction was significantly negative for EC > −.19 SDs. The pattern was the same as described for Samples 1 and 2 (see Fig. 1a, dashed lines).[5] NE's association with symptoms was significant when PE was low (*B* = .51, $p < .001$) but not high (*B* = .10, $p = .29$). However, when EC was low NE's association with symptoms was significant when PE was high (*B* = .38, $p < .001$) and low (*B* = .36, $p < .001$). The NE × EC interaction was significantly negative for PE > 1.74 SDs. The pattern was the same as the negative interactions seen in Samples 1 and 2 (see Fig. 1a, grey lines). NE's association with symptoms was significant when EC was low (*B* = .51, $p < .001$) but not high (*B* = .10, $p = .29$). In contrast, at low PE, NE's association with symptoms was significant when EC was high (*B* = .51, $p < .001$) and low (*B* = .36, $p < .001$). Finally, the PE × EC interaction was significantly positive for NE < −1.35. The pattern was very similar to the positive interaction seen at low NE in Sample 1 (see Fig. 1b, grey lines). PE's association with symptoms was significant when EC was low (*B* = −.25, $p = .002$) but not high (*B* = −.04,

[5] The graphs for Sample 3 can be found in the online Supplemental material.

Table 4
Sample 3 regression analyses.

Step/variables added	CDI				RCMAS			
	R^2	ΔR^2	*B* (*SE*) at final step	*sr* at final step	R^2	ΔR^2	*B* (*SE*) at final step	*sr* at final step
Step 1	.389***				.369***			
Constant			−.02 (.04)				−.10 (.05)	
Sex			.00 (.03)	.00			.19** (.07)	.10**
Age			−.05 (.03)	−.05			−.14*** (.03)	−.13***
NE			.34*** (.04)	.30***			.40*** (.04)	.35***
PE			−.24*** (.04)	−.21***			−.11** (.04)	−.10**
EC			−.33*** (.04)	−.28***			−.30*** (.04)	−.26***
Step 2	.396***	.007†			.375***	.007		
NE × PE			−.08* (.04)	−.07*			−.05 (.04)	−.04
NE × EC			−.03 (.04)	−.03			.06 (.04)	.05
PE × EC			.00 (.03)	.00			.04 (.04)	.04
Step 3	.400***	.004†			.376***	.001		
NE × PE × EC			−.06† (.03)	−.06†			−.03 (.05)	−.02

Note: *n* = 597; NE = trait PANAS NA scale, PE = trait PANAS PA, EC = ECS-P/LD scale; all main effect variables were standardized; *sr* = semi-partial correlation coefficient.
† $p = .056$.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

p = .56). In contrast, at high NE, PE's association with symptoms was significant when EC was high (*B* = −.46, *p* < .001) and low (*B* = −.23, *p* = .01). Similarly, when NE was low, as in the positive pattern in Sample 1 (see Fig. 1c, dashed lines) EC's association with symptoms was significant when PE was low (*B* = −.40, *p* < .001) but not high (*B* = −.19, *p* = .021). In contrast, at high NE, EC's association with symptoms was significant when PE was high (*B* = −.48, *p* < .001) but not low (*B* = −.25, *p* = .016). This follows the negative interaction pattern seen in Samples 1 and 2 (see Fig. 1c, solid lines), although that form of the interaction did not reach significance in this sample.

RCMAS. Preliminary analyses revealed a single case with high influence on model fit (DFFITS = 1.00). With that case included, the NE × PE × EC interaction was not significant (*sr* = −.045, *p* = .168) and, as shown in Table 3, it remained non-significant when the case was deleted. The only terms reaching significance were those for Sex, Age, NE, PE, and EC.

3.3.4. Sample 4

CDI. The initial regression analysis revealed a single case with high influence on model fit (DFFITS = 1.72, SDR = 7.36). With that case in the model the NE × PE × EC interaction was significant (*sr* = .11, *p* = .036) and, as shown in Table 4, it remained significant when the case was deleted. However, dropping the case in question increased overall model fit substantially (from R^2 = .44–.51). In addition to the 3-way interaction term, significant effects were found for NE and EC as well as the NE × EC and PE × EC interactions.

PROCESS revealed that the NE × PE interaction term was significantly negative for EC < −1.08 and significantly positive for EC > 1.86 SDs. The pattern at low EC was the same as the negative interactions seen in Samples 1–3 (see Fig. 1a, dashed lines).[6] NE's association with symptoms was significant at low PE (*B* = .58, *p* < .001) but not high (*B* = −.11, *p* = .49). The positive interaction pattern seen at high EC was unexpected, weak and unique to this sample. NE's association with symptoms was stronger when PE was high (*B* = .30, *p* = .04) versus low (*B* = −.11, *p* = .49), but neither simple slope was significant. The NE × EC interaction was significantly negative for PE < .21 SDs. This negative interaction pattern was the same as was seen in Samples 1–3 (see Fig. 1a, grey lines): At low PE, NE's association with symptoms was significant when EC was low (*B* = .58, *p* < .001) but not high (*B* = −.11, *p* = .49). In contrast, at high PE, NE's association with symptoms was not significant when EC was high (*B* = .30, *p* = .04) or low (*B* = .20, *p* = .12). Finally, the PE × EC interaction was significantly positive for NE > −.28 SDs. This positive interaction pattern was the same as was seen in Samples 1 and 3 (see Fig. 1b, grey lines). PE's association with symptoms was significant when EC was low (*B* = −.45, *p* < .001) but not high (*B* = .37, *p* = .06). In contrast, at low NE, PE's association with symptoms was not significant when EC was high (*B* = −.08, *p* = .51) or low (*B* = −.05, *p* = .74). Similarly, at high NE, EC's association with symptoms was significant when PE was low (*B* = −.94, *p* < .001) but not high (*B* = −.23, *p* = .064; see Fig. 1c, dashed lines). In contrast, at low NE, EC's association with symptoms was not significant when PE was low (*B* = −.26, *p* = .047) or high (*B* = −.15, *p* = .31).

RCMAS. The initial regression analysis revealed a single case with high influence on model fit (DFFITS = 1.58, SDR = 4.23). With that case in the model the NE × PE × EC interaction was not significant (*sr* = .07, *p* = .165) and, as shown in Table 4, it remained non-significant when the case was deleted. The only significant terms in the regression model were the NE and EC main effects.

3.3.5. Sample 5

BDI. Preliminary analyses revealed two cases with high influence on model fit (DFFITS > 1.06). With those cases in the model the NE × PE × EC interaction was not significant (*sr* = .07, *p* = .128). However, as shown in Table 6, when those cases were dropped, that interaction became significant (*sr* = .09, *p* = .041).[7] In addition, significant effects were found for the NE, PE, and EC main effects as well as the NE × PE and NE × EC interactions.

PROCESS revealed that the NE × PE interaction was significantly negative for EC < .76 SDs. This negative interaction pattern was the same as was seen in Samples 1–4 (see Fig. 1a, dashed lines).[8] NE's association with symptoms was significant when PE was low (*B* = .68, *p* < .001) but not high (*B* = .19, *p* = .10). However, at high EC, NE's association with symptoms was significant when PE was high (*B* = .29, *p* = .003) and low (*B* = .41, *p* < .001). The NE × EC interaction was significantly negative for PE < −1.25 SDs. This negative interaction pattern was the same as was seen in Samples 1–4 (see Fig. 1a, grey lines). NE's association with symptoms was stronger

[6] The graphs for Sample 4 can be found in the online Supplemental material.

[7] As mentioned in footnote 2, we also tested a model using the total negative affect and extraversion/surgency scores from the ATQ in which the three-way interaction was also significant. This analysis can be found in the online supplemental material.

[8] The graphs for Sample 5 can be found in the online Supplemental material.

Table 5
Sample 4 regression analyses.

Step/variables added	CDI				RCMAS			
	R^2	ΔR^2	*B* (*SE*) at final step	*sr* at final step	R^2	ΔR^2	*B* (*SE*) at final step	*sr* at final step
Step 1	.438***				.448***			
Constant			−.10 (.06)				−.11 (.07)	
Sex			−.02 (.05)	−.02			.15 (.11)	.07
Age			.02 (.05)	.02			−.03 (.06)	−.03
NE			.26*** (.06)	.21***			.38*** (.06)	.31***
PE			−.06 (.06)	−.05			−.04 (.06)	−.04
EC			−.39*** (.06)	−.33***			−.34*** (.06)	−.29
Step 2	.496***	.058***			.456***	.008		
NE × PE			.00 (.06)	.00			.05 (.07)	.04
NE × EC			−.12** (.04)	−.13*			−.05 (.05)	−.06
PE × EC			.14** (.05)	.13**			.06 (.06)	.05
Step 3	.513***	.016**			.456***	.000		
NE × PE × EC			.13** (.05)	.13*			.02 (.06)	.02

Note: *n* = 209; NE = trait PANAS NA scale, PE = trait PANAS PA, EC = ECS-P/LD scale; all main effect variables were standardized; *sr* = semi-partial correlation coefficient.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 6
Sample 5 regression analysis.

Step/variables added	BDI			
	R^2	ΔR^2	*B* (*SE*) at final step	*sr* at final step
Step 1	.362***			
Constant			−.02 (.05)	
Sex			.02 (.06)	.02
Age			.02 (.05)	.02
NE			.40*** (.06)	.33***
PE			−.33*** (.05)	−.32***
EC			−.12** (.05)	−.12**
Step 2	.381***	.020**		
NE × PE			−.13** (.04)	−.14*
NE × EC			−.03 (.05)	−.03
PE × EC			.04 (.04)	.05
Step 3	.390***	.009*		
NE × PE × EC			.06* (.03)	.09*

Note: *n* = 307; NE = sum of ATQ-sadness and ATQ-fear subscales, PE = ATQ-positive affect and ATQ-sociability subscales, EC = ATQ-EC scale; all main effect variables were standardized; *sr* = semi-partial correlation coefficient.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 7
Combined sample regression analysis.

Step/variables added	*z*-Depression			
	R^2	ΔR^2	*B* (*SE*) at final step	*sr* at final step
Step 1	.411***			
Constant			−.03 (.02)	
Sex			.00 (.02)	.00
Age			.00 (.02)	.00
NE			.38*** (.02)	.34***
PE			−.27*** (.02)	−.25***
EC			−.28*** (.02)	−.26***
Step 2	.427***	.016***		
NE × PE			−.10*** (.02)	−.10***
NE × EC			−.05*** (.02)	−.06**
PE × EC			.03 (.02)	.03
Step 3	.429***	.002*		
NE × PE × EC			−.04* (.02)	−.04*

Note: *n* = 1888; all main effect variables were standardized; *sr* = semi-partial correlation coefficient.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

when EC was low ($B = .68$, $p < .001$) versus high ($B = .41$, $p < .001$). In contrast, at high PE, NE was significantly associated with symptoms when EC was high ($B = .29$, $p = .003$) but not low ($B = .19$, $p = .10$). This reflects the positive interaction pattern seen in Sample 1 (Fig. 1a, black lines), although that form of the interaction was not significant when PE was high in this sample. Finally, the PE × EC interaction was significantly positive for NE > 1.65 SDs. This positive interaction pattern was the same as was seen in Samples 1, 3, and 4 (see Fig. 1b, grey lines). PE's association with symptoms was stronger when EC was low ($B = -.67$, $p < .001$) versus high ($B = -.35$, $p = .002$). In contrast, at low NE, PE's association with symptoms was significant when EC was high ($B = -.22$, $p < .01$) but not low ($B = -.13$, $p = .25$). This reflects the negative interaction pattern seen in Samples 1 and 2 (Fig. 1a, black lines), although that form of the interaction was not significant when PE was high in this sample. Similarly, when NE was high (see Fig. 1c, solid lines), EC's association with symptoms was significant when PE was low ($B = -.32$, $p < .01$) but not high ($B = -.02$, $p = .86$). However, when NE was low, EC was not significantly associated with symptoms when PE was low ($B = -.04$, $p = .62$) or high ($B = -.12$, $p = .20$).

3.3.6. Combined sample

Because the pattern of the 3-way interaction varied somewhat across samples, we sought to arrive at a more reliable estimate of its pattern by combining the five samples to create a single sample of 1890 cases (47.7% female; $M_{age} = 14.1$, range = 9–20 years). Because measures varied across samples, they were standardized before being combined. An initial regression analysis of this combined sample identified two cases with high influence on model fit (DFFITS > 1.35). Prior to dropping these points the 3-way interaction was significant ($sr = -.040$ $p = .021$) and, as shown in Table 7 it remained so after they were dropped ($sr = -.044$, $p = .011$).[9]

PROCESS revealed that the NE × PE interaction was significantly negative for EC > −1.31 SDs. This pattern is depicted in Fig. 2a and is the same as the negative interaction pattern seen in Samples 1–5. When EC was high (dashed lines), NE was more strongly associated with symptoms when PE was low (black line; $B = .38$, $p < .001$) versus high (grey line; $B = .12$, $p = .009$). In contrast, at low EC, NE's correlation with symptoms was significant when PE was high

[9] Supplementary analyses showed that the NE × PE × EC interaction was not moderated by either age or sex.

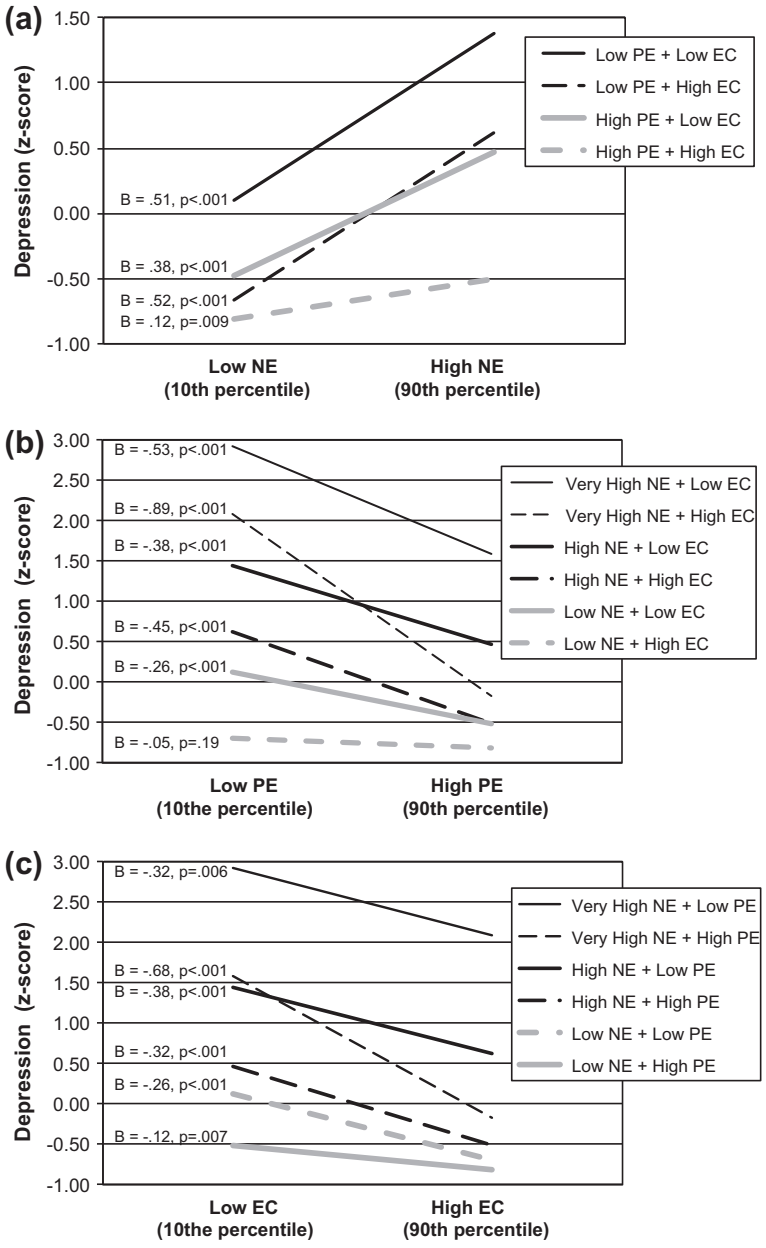

Fig. 2. Conditional 2-way interaction patterns in combined sample. (a) NE predicting depressive symptoms at combinations of high and low PE and EC. (b) PE predicting depressive symptoms at combinations of high and low NE and EC. (c) EC predicting depressive symptoms at combinations of high and low NE and PE.

($B = .52$, $p < .001$) and low ($B = .51$, $p < .001$). The NE × EC interaction was significantly negative for PE > −.42 SDs. Although the positive NE × EC interaction pattern seen in Sample 1 (see Fig. 1a, black lines) emerged at very low levels of PE (i.e., PE ⩽ −1.53), it did not achieve significance. As shown in Fig. 2a, the negative interaction pattern seen at high PE was the same as was seen in Samples 1–5. Specifically, NE's association with symptoms was stronger when EC was low ($B = .38$, $p < .001$) versus high ($B = .12$, $p = .009$). In contrast, at low PE, NE's correlation with symptoms was significant when EC was high ($B = .52$, $p < .001$) and low ($B = .51$, $p < .001$). Finally, the PE × EC interaction was significantly positive for NE < −.06 SDs and significantly negative for NE > 4.30 SDs. As shown in Fig. 2b, when NE was low (grey lines), PE was significantly negatively associated with symptoms when EC was low (solid line; $B = -.26$, $p < .001$) but not high (dashed line, $B = -.05$, $p = .19$). At high NE (i.e., the 90th percentile: NE = 1.21 SDs; thick black lines), PE's association with symptoms was similar when EC was high ($B = -.45$, $p < .001$) and low ($B = -.38$, $p < .001$). However, Fig. 2b also includes lines depicting the negative PE × EC interaction pattern at very high NE (i.e., NE = 4.30 SDs; thin black lines). That pattern was such that PE was more strongly associated with symptoms when EC was high (dashed line; $B = -.89$, $p < .001$) versus low (solid line; $B = -.53$, $p < .001$). Similarly, as shown in Fig. 2c, when NE was low (grey lines), the positive interaction pattern was such that EC's association with symptoms was stronger when PE was low (dashed line; $B = -.26$, $p < .001$) versus high (solid line; $B = -.12$, $p = .007$). In contrast, when NE was high (i.e., 90th percentile; thick black lines), EC's association with symptoms was similar when PE was high (dashed line; $B = -.32$, $p < .001$) and low (solid line; $B = -.38$, $p < .001$). However, in the negative interaction pattern seen at very high levels of NE (i.e., NE = 4.30 SDs; thin black lines), EC's association with symptoms was stronger when PE was high (solid line; $B = -.68$, $p < .001$) versus low (dashed line; $B = -.32$, $p = .006$).

4. Conclusions

This study tested the replicability of a 3-way interaction among the temperament dimensions of NE, PE, and EC in relation to depressive symptoms. First reported by Dinovo and Vasey (2011), this interaction is in keeping with expectations regarding the moderating impact of individual differences in executive-regulatory capacity (i.e., EC) on the associations of high levels of NE and low levels of PE with depressive symptoms given that these latter dimensions themselves interact with one another. We sought to replicate this NE × PE × EC interaction in five independent samples. These samples also provided the first tests of this interaction in youth. Consistent with expectation, the NE × PE × EC interaction achieved significance in four samples as well as in a combined sample and approached significance in the fifth sample. Also consistent with expectation, the NE × PE × EC interaction was not associated with anxious symptoms in any of the four samples in which it was tested. Thus, our results provide compelling evidence for the replicability of the 3-way interaction, its occurrence in youth, and for its specificity to depressive versus anxious symptoms.

Given the 3-way interaction's replicability, it is important to begin to characterize the conditional 2-way interactions. Most consistent was the NE × PE interaction, which was significantly negative in all five samples and in the combined sample. In all cases the pattern was such that NE's positive association with depressive symptoms was strongest when PE was low (and PE's negative association with symptoms was strongest when NE was high versus low). The range of EC scores over which the NE × PE interaction was significant varied across samples but included average levels of EC in four of the five samples plus the combined sample. Thus, it appears that it can be expected to emerge in most unselected samples.

The NE × EC interaction was also significantly negative in all five samples and the combined sample. However, a significant positive interaction pattern was seen in one sample. Furthermore, examination of the conditional interaction tests revealed that, although not significant, this positive interaction pattern emerged in the other four samples and in the combined sample. The negative pattern was such that NE's association with symptoms was strongest when EC was low (i.e., the slope declined as EC went up). The range of PE scores at which this pattern emerged varied substantially across samples. In two samples this pattern emerged only at lower levels of PE whereas it was seen at higher levels of PE in three samples plus the combined sample. It was significant at average levels of PE in only two samples plus the combined sample. The positive interaction pattern tended to emerge when PE was low (in three samples plus the combined sample). This positive pattern reflects the fact that when PE and EC were *both* low, predicted levels of depressive symptoms were generally high regardless of the level of NE. Seen from the standpoint of EC's effect, when PE was low and NE was high, EC had a weak effect compared to when PE was low but NE was low.

The PE × EC interaction was also significant in all five samples and the combined sample. However, its pattern varied markedly. A positive interaction pattern was significant in four samples plus the combined sample and it was present but not significant in the remaining sample (i.e., Sample 2). However, a negative interaction pattern was significant in two samples plus the combined sample and approached significance in two other samples (i.e., Sample 3 and 5). The positive interaction pattern was such that the negative correlation between PE and symptoms was stronger when EC was low versus high. That pattern was strongest at low levels of NE in two samples plus the combined sample and at high levels of NE in two samples. It was significant at average levels of NE in only three samples. Viewed from the perspective of EC, in this positive interaction pattern EC was negatively correlated with symptoms when NE and PE were both low but not when NE was low and PE was high. This pattern suggests a floor effect reflecting the fact that depressive symptoms are very low when NE is low and PE is high, leaving little room for an effect of EC. The negative PE × EC interaction pattern was only seen at high levels of NE. It was such that PE was more strongly associated with depressive symptoms when EC was high versus low. This reflects the fact that, when NE was very high and EC was low, depressive symptoms were generally high and PE had a weaker effect than when EC was high. That pattern can be seen best in Fig. 2b (thin black lines). Similarly, from the standpoint of EC's association with symptoms, when NE was very high, EC was more strongly associated with symptoms when PE was high versus low. That is, when NE was very high and PE was low, depressive symptoms were generally high and high levels of EC had a weaker effect than when PE was high. This pattern suggests that the synergistic combination of high NE and low PE may be associated with depressive symptoms that are especially difficult to overcome through effortful control.

These results advance the literature in several important ways. First, combined with past studies (e.g., Joiner & Lonigan, 2000), the fact that we consistently found the NE × PE interaction to be significant on average leaves little doubt that this interaction must be explicitly considered in models relating these dimensions to depressive symptoms. For example, the tripartite model (e.g., Clark & Watson, 1991; Clark et al., 1994) posits that depressive symptoms reflect high levels of NE and low levels of PE but does not clearly address the possibility that NE and PE may interact. The importance of explicitly considering this interaction in the tripartite model is most clearly seen in the negative pattern of the PE × EC interaction (see Fig. 1c, solid black line and Fig. 2c, thin solid black line) which, as noted above, suggests that the synergistic combination of high NE and low PE is associated with depressive symptoms that are difficult for EC to overcome and therefore may be particularly likely to persist.

Second, our results also add to the tripartite model by showing that consideration of EC is important, not only because of its main effect, but because of its moderating impact on the links between NE and PE and their interaction on the one hand and depressive symptoms on the other. Furthermore, the NE × PE × EC interaction allows a more nuanced understanding of the relations between temperament and symptoms, leading to enhanced prediction of what types of individuals are likely to experience depressive symptoms (Klein et al., 2011). For example, the tripartite model would not predict that depressive symptoms can be well *below* average when NE is very high or when PE is very low, but the NE × PE × EC interaction provides a context in which to understand such outcomes. Across samples it is striking that in the presence of the combination of high PE and high EC, high levels of NE consistently predicted levels of depressive symptoms that were well below average. Thus, it appears that the combination of high PE and high EC may minimize the depressogenic aspects of high NE (e.g., brooding, passive avoidance; see also Vasey et al., 2013). Similarly, in most samples low levels of PE predicted low levels of depressive symptoms in the presence of low NE and high EC, suggesting that, in the absence of high NE, high levels of EC may minimize the depressogenic aspects of low PE (e.g., by enabling active approach responses despite a lack of anticipated rewards).

The 3-way interaction also appears to help explain inconsistencies in the literature regarding the component 2-way interactions. As noted above, the NE × PE interaction was consistently significant at average levels of EC, but the NE × EC interaction and, especially the PE × EC interaction, were often not significant at average levels of the third dimension. These results mirror the pattern seen in previous studies, which have most consistently found evidence

for the NE × PE interaction whereas evidence for the NE × EC interaction and, especially, the PE × EC interactions has been rare. Consequently, it is important for future studies to consider the 3-way interaction. Efforts to find NE × EC or PE × EC interactions without consideration of the third variable appear particularly unlikely to bear fruit. However, the reasons for the variability in the PE × EC interaction and, to a lesser extent the NE × EC interaction, are unclear and will be an important focus of future research.

4.1. Limitations and future directions

Several issues pertaining to these results warrant discussion. First, the samples used in this study were unselected and such samples provide a limited context for studying interactions (McClelland & Judd, 1993). This limitation stems from the fact that most of the variance in the interacting dimensions, NE, PE, and EC in this case, is confined to the middle of each dimension. Thus, most members in any given sample will comprise a sphere in the center of the space (in this case a cube) defined by the interacting dimensions. Individuals falling at the corners of the cube are most important for testing a 3-way interaction. Even our combined sample of 1890 cases, may lack sufficient numbers of individuals at all relevant corners of the cube to yield an accurate picture of the patterns of the conditional 2-way interactions. It will be important for future studies to take steps to maximize the number of individuals falling at the corners of the cube through oversampling, as recommended by McClelland and Judd (1993). Related to that, it will be important for future studies to include clinically depressed individuals. It seems likely that the synergistic impact of high NE plus low PE may be particularly strong in such cases and hardest to overcome through EC.

It will also be important to test the effect of the NE × PE × EC interaction prospectively. Thus far it has only been examined in relation to concurrent symptoms. Whereas prospective evidence consistently supports the NE × PE interaction, such evidence for the NE × EC interaction is mixed and lacking entirely for the PE × EC interaction, suggesting they are conditional upon the third dimension. For example, although low levels of PE predict increased symptoms over time (Klein et al., 2011), the current results suggest that, when EC is high, they may not do so unless combined with high NE. Alternatively, although the current study suggests that EC has little impact when NE was high and PE was low, it may be that over time low levels of EC will predict a chronic or deteriorating course among those high in NE and low in PE. However, such possibilities await future research.

Although the results of the present study combined with previous research (Dinovo & Vasey, 2011) leave little doubt about the presence of the 3-way interaction in relation to depressive symptoms, one might question the importance of this interaction given the small increment in R^2 that is typically seen (.004–.016 in the current study). However, as noted above, the unselected nature of the samples in this study limits the relevance of increments in R^2 for interpreting the importance of the interaction. Because the 3-way interaction is largely irrelevant to those individuals in the center sphere, the amount of variance it can account for in an unselected sample is quite small (McClelland & Judd, 1993). We suggest that the NE × PE × EC interaction is more relevant to individuals falling at the confluence of the extremes on NE, PE, and EC (i.e., those in the corners of the cube defined by NE, PE, EC) and, thus, for those individuals the increments in R^2 in the present study understate the interaction's importance.

Whereas we expected that the 3-way interaction would not be associated with anxious symptoms, we were surprised that none of the samples yielded a significant NE × EC interaction given that it has been previously linked to anxious symptoms (e.g., Lonigan et al., 2004). However, more recently Lonigan and colleagues have clarified this association, reporting that whereas it emerges for several specific anxiety disorder symptom dimensions (i.e., Generalized Anxiety Disorder, Social Phobia, and Panic/Agoraphobia) it tends not to emerge for broad measures of anxious symptoms such as were used in the present study (Lonigan, Phillips, Wilson, & Allan, 2011). Given that, future research should examine the 3-way interaction in the context of specific anxiety disorder symptoms dimensions to further clarify the extent to which it is specific to depressive symptoms. In particular, we suggest it may be most relevant for anxiety disorder symptoms that are associated with low levels of PE such as social phobia and agoraphobia (Bienvenu & Stein, 2003; Mineka et al., 1998).

Finally, our reliance on self-report measures increases the likelihood that some part of the observed relations may be a product of shared method variance. Future studies would benefit from utilizing measures across multiple modalities. For example, Joorman and colleagues have used several performance-based measures that tap negative emotionality (e.g., negative priming task, Joorman, 2006; negative mood induction, Joormann & Gotlib, 2008) and aspects of effortful control (e.g. working memory task, Joormann & Gotlib, 2008). Physiological measures of effortful control such as resting heart rate variability (Thayer, Hansen, Saus-Rose, & Johnsen, 2009) should also be considered.

4.2. Summary

In sum, the present study provides the first tests of the NE × PE × EC interaction in youth and replicates this interaction across five independent samples predicting concurrent symptoms of depression. Results support the robust nature of the NE × PE interaction, which was typically significant at average levels of EC and thus can be expected in most samples. In contrast, the NE × EC and PE × EC interactions were typically *not* significant on average. Instead, they achieved significance primarily at high or low levels of the third variable, which helps to explain the mixed findings in studies to date. Finally, results indicated that the NE × PE × EC interaction is specific to depressive, but not anxious, symptoms.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jrp.2013.09.001.

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