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# Temperamental factors in remitted depression:

# The role of effortful control and attentional mechanisms

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**Abstract**

Background: Temperamental effortful control and attentional networks are increasingly viewed as important underlying processes in depression and anxiety. However, it is still unknown whether these factors facilitate depressive and anxiety symptoms in the general population and, more specifically, in remitted depressed individuals. Methods: We investigated to what extent effortful control and attentional networks (i.e., Attention Network Task) explain concurrent depressive and anxious symptoms in healthy individuals (n = 270) and remitted depressed individuals (n = 90). Both samples were highly representative of the US population. Results: Increased effortful control predicted a substantial decrease in symptoms of both depression and anxiety in the whole sample, whereas decreased efficiency of executive attention predicted a modest increase in depressive symptoms. Remitted depressed individuals did not show less effortful control nor less efficient attentional networks than healthy individuals. Moreover, clinical status did not moderate the relationship between temperamental factors and either depressive or anxiety symptoms. Limitations: Limitations include the cross-sectional nature of the study. Conclusions: Our study shows that temperamental effortful control represents an important transdiagnostic process for depressive and anxiety symptoms in adults.

**Keywords:** temperament, effortful control, ANT, depression, anxiety, remitted depression

## Introduction

Major depression (MDD) is a highly prevalent disorder (i.e., lifetime prevalence 15-30%; Kessler et al., 2003), characterized by severe consequences in terms of well-being (Hays, Wells, Sherbourne, Rogers, & Spritzer, 1995), physical health (Barefoot & Schroll, 1996), and psychosocial functioning (Fried & Nesse, 2014). Despite moderate success in reducing symptoms in the short-term, the high rate of recurrence of MDD in the long-term (Hardeveld, Spijker, De Graaf, Nolen, & Beekman, 2010) indicates that current treatments do no effectively target important factors that render individuals prone to the development and recurrence of depression (Marchetti, Koster, Sonuga-Barke, & De Raedt, 2012).

Although a variety of risk factors have been identified, temperament is increasingly garnering researchers' attention as a potential major vulnerability to depression (Compas, Connor-Smith, & Jaser, 2004; Hudson & Rapee, 2004; Mezulis, Hyde, & Abramson, 2006; Ono et al., 2002). Temperament is broadly defined as constitutionally based individual differences in (1) attentional, motor, and emotional reactivity to stimuli and (2) self-regulation modulating such reactivity (Rothbart, Sheese, & Posner, 2007). In other words, temperament constitutes the biological base of the person that, in interaction with experience, shapes how the individual perceives and reacts to the environment (Rothbart & Ahadi, 1994). In line with this view, temperamental dimensions have been associated with mechanisms crucial for response to stressful stimuli, such as coping (Rueda & Rothbart, 2009) and emotion regulation (Rothbart, Sheese, & Posner, 2014).

However, research on depression has primarily investigated the role of temperamental reactivity (i.e., negative affectivity; Derryberry & Reed, 1994; Lengua & Long, 2002; Mezulis, Priess, & Hyde, 2011), whereas far less attention has been given to the self-regulatory component. Specifically, self-regulation refers to modulation of emotional reactions and behavior by means of both effortful control and attentional mechanisms (Rothbart & Bates, 1998; Rothbart et al., 2007).

Effortful control is the ability to activate or inhibit behavior and voluntarily deploy attention as required to adaptively fit the context (i.e., being able to refocus on a task, after being distracted; Rothbart & Bates, 1998). Compared to similar constructs (e.g., cognitive control), effortful control is substantially more focused on emotion-laden contexts, with particular emphasis on socioemotional and adaptive functioning (Zhou, Chen, & Main, 2012). Moreover, it has been noted that effortful control is under the influence of attentional control mechanisms, such as executive attention and, perhaps, orienting and alerting networks (Petersen & Posner, 2012; Posner & Rothbart, 1998). Executive attention is defined as the ability to resolve conflicts among different responses and it requires top-down attentional control, while orienting consists of selecting information arising from different sensory inputs. Finally, alerting refers to the ability to stay vigilant to incoming stimuli. These three mechanisms are usually measured with the Attention Network Task (ANT; Fan, McCandliss, Sommer, Raz, & Posner, 2002).

Recently, a growing amount of cross-sectional and longitudinal evidence indicates that inefficient temperamental self-regulation puts the individual at risk to develop depression and depressive symptoms (e.g., Laceulle, Ormel, Vollebergh, van Aken, & Nederhof, 2014; Loukas & Robinson, 2004; Verstraeten, Vasey, Raes, & Bijttebier, 2009, but see Loukas & Roalson, 2006). However, the vast majority of research has specifically focused on children and adolescents, while the role of self-regulation in adult depression remains unknown. This is rather unfortunate, as temperament exerts its influence throughout the whole lifespan, from childhood (Rothbart et al., 2007) to old age (Mehrabian & Blum, 1996). Hence, our first goal was to investigate whether low levels of efficient effortful control and less efficient attentional mechanisms explain concurrent depressive symptoms in a representative (US) community sample of adult individuals.

There is ample evidence that remitted depressed individuals (i.e., RMD) experience more (residual) depressive symptoms and are at higher risk to develop additional depressive episodes than healthy individuals (i.e., HC) (Fava, Fabbri, & Sonino, 2002; Keller, 2003). Moreover, studies show that RMD individuals report lower levels of effortful control (Kanske, Heissler, Schonfelder, & Wessa, 2012) and their neurophysiological activation related to conflict-related attentional control (i.e., N450) is influenced by the number of previous depressive episodes (Vanderhasselt & De Raedt, 2009). Similarly, impaired cognitive control was found to predict future rumination and depressive symptoms in RMD patients (Demeyer, De Lissnyder, Koster, & De Raedt, 2012).

The reviewed evidence suggests that less efficient self-regulation may function as an aggravating factor in RMD individuals. This gives rise to two non-mutually exclusive hypotheses. As compared to HC individuals, RMD patients may show lower levels of effortful control and less efficient attentional networks (i.e., mean-level difference hypothesis). It could also be that a prior history of major depression moderates the relationship between self-regulation mechanisms and depressive symptoms (i.e., regression slope difference hypothesis), with RMD patients showing a tighter association between temperamental factors and symptoms than HC individuals. In sum, our second goal was to investigate if and how impaired self-regulation confers additional risk in RMD patients.

The role of temperamental self-regulation mechanisms, however, is not limited to depression, as developmental studies have associated such processes with anxiety as well (i.e., internalizing disorders; Muris, van der Pennen, Sigmond, & Mayer, 2008). Given the high comorbidity between depression and anxiety (Mineka, Watson, & Clark, 1998), these two disorders likely share important underlying mechanisms, among which self-regulation appears to be a good candidate. In keeping with this, previous literature shows that in adults effortful control and attentional mechanisms are associated not only with depression, but with anxiety symptoms as well (Kanske & Kotz, 2012; Moriya & Tanno, 2008, 2009). Hence, our third goal was to investigate if impaired effortful control and inefficient attentional mechanisms are associated with higher anxiety levels in the general population and/or RMD individuals selectively.

In conclusion, our cross-sectional study was designed to investigate the relationship between temperamental self-regulation and symptoms of depression and anxiety in a representative (US) community sample of adult individuals with and without a history of depressive episodes.

## Method

Participants. The sample consisted of 90 remitted depressed (RMD) patients and 270 healthy controls (HC). The RMD group had the following demographic features: female = 71.1%; age = 39.1 ± 14.2 (18-63); ethnicity = 8.9% Hispanic and 91.1% not Hispanic; race = 78.9% Caucasian, 17.8% black or African American; 3.3% other race. Moreover, 60 individuals were in either partial or full remission from a single depressive episode and 30 individuals in either partial or full remission from recurrent depression. Besides, 29 RMD patients were currently affected by or had an history of posttraumatic stress disorder (8), panic disorder with or without agoraphobia (8), specific phobia (5), generalized anxiety disorder (4), social phobia (3), or other anxiety-provoking conditions (1). Finally, 26 persons reported receiving antidepressant and/or anxiolytic medication. The HC group had the following characteristics: female = 69.6%; age = 38.2 ± 15.1 (18-67); ethnicity = 10% Hispanic and 90% not Hispanic; race = 60.7% Caucasian; 24.8% black or African American, 14.5% other race. Six persons of the HC group received antidepressant and/or anxiolytic medication.

This sample was derived from the enhanced Nathan Kline Institute-Rockland Sample (NKI-RS; Nooner et al., 2012). The NKI-RS is a community-ascertained, lifespan sample in which age, ethnicity, and socioeconomic status are representative of Rockland County, New

York. Importantly, the ethnic and socioeconomic features of Rockland County mirror those of the United Stated, hence increasing the generalizability of the NKI-RS sample. The inclusion criteria for the RMD group were being in either full or partial remission from either a single or recurrent episode. Although comorbidity was in general allowed, patients with a current diagnosis of alcohol/drug dependence, psychotic or bipolar disorder, obsessive-compulsive disorder, or a history of severe head trauma were excluded (Mocking et al., 2016). HC were included if they did not report either current or past mental disorders or a history of severe head trauma. Clinical status was assessed with the Structured Clinical Interview for DSM-IV Non-Patient Edition (SCID; First, Spitzer, Gibbon, & Williams, 2002), which was administered by mental health professionals (i.e., psychiatrists, psychologists, licensed clinical social worker, etc.). All interviewers were thoroughly trained and supervised during the study by senior SCID raters. Importantly, for all participants, a second certified rater conducted a scoring verification review and conflicting conclusions were reconciled.

The NKI-RS project was approved by the Institutional Review Board at Montclair State University, New Jersey and the present study was approved by the Ethical Committee at Ghent University, Belgium.

Measures.

Adult Temperament Questionnaire – Effortful Control (ATQ-EF; Evans & Rothbart, 2007). The ATQ is a 77-item self-report used to assess temperament in adults. In our study we reported only the effortful scale (ATQ-EF), which lists 19 items measured on a 7-point Likert scale (from 1 = ‘extremely untrue of you’ to 7 = ‘extremely true of you’) (e.g., “I can keep performing a task even when I would rather not do it”, “It’s often hard for me to alternate between two different tasks”, “It is easy for me to inhibit fun behavior that would be inappropriate”). Because effortful control was the main variable of interest in our study, we did not report and analyze its three subscales (e.g., inhibitory control, activation control, and attentional control). In our study, Cronbach's alpha for ATQ-EF was .75. Higher levels of ATQ-EF indicate more effortful control.

Beck Depression Inventory – 2nd Edition (BDI-II; Beck, Steer, & Brown, 1996). The BDI-II is a 21-item self-reported questionnaire to assess depressive symptoms. Each item consists of a list of four statements arranged in increasing severity (from 0 = 'absent' to 3 = 'severe') about a specific symptom of depression. In our study, Cronbach's alpha for BDI-II was .89.

State-Trait Anxiety Inventory – Trait (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). The STAI-T is a 20-item self-report questionnaire that measures anxiety symptoms. Each item is measured on a 4-point Likert scale (from 1 = 'almost never' to 4 = 'almost always'). In our study, Cronbach's alpha for STAI-T was .93.

Attention Network Task (ANT; Fan et al., 2002). ANT is a computer-based task, designed to measure executive attention (also known as conflict), alerting, and orienting (Figure 1). After the initial fixation crosshair of random variable duration (i.e., 400-1600ms), one of four possible warning cues appeared for 100ms (e.g., no cue, centre cue, double cue, spatial cue). After another fixation phase of 400ms, both the target and the flankers appeared until the participant responded or a maximum of 1700ms had elapsed. The target stimulus (leftward or rightward arrowhead) was flanked on either side by two arrows pointing in the same direction (congruent condition), opposite direction (incongruent condition), or by simple lines (neutral condition). Participants were required to indicate the target direction by pressing one of the two input keys on a keyboard. Then, an inter-trial interval of 3500ms took place. Each session consisted of 24 practice trials, followed by 3 experimental blocks of 96 trials. Alerting, orienting, and conflict were computed as derived by Fan and colleagues (2002) (see Figure 1). Higher scores for each of the three indexes indicate less efficient attentional mechanisms.

Note that additional measures and paradigms, unrelated to the current study's goal, were also administered (Nooner et al., 2012).

Data Analysis.

After inspecting the descriptive statistics and correlations of the variables of interest in both the RMD and the HC groups, we tested whether the two groups differed with respect to their psychopathological symptoms (i.e., depressive symptoms, and anxiety symptoms). First, we regressed BDI-II and STAI scores on effortful control (ATQ-EF), alerting effect, orienting effect, and executive attention, along with prior history of MDD. This analysis was carried out on the whole sample. Note that higher scores at the ATQ-EF indicate more efficient effortful control, while higher scores at all ANT indexes (e.g., alerting, orienting, and executive attention) indicate less efficient attentional networks. Second, we tested whether RMD patients reported less efficient effortful control and attentional mechanisms than HC individuals (i.e., mean-level difference hypothesis). Third, we investigated whether a prior history of MDD moderated the predictive role of self-regulation mechanisms with respect to BDI-II and STAI (i.e., regression slope difference hypothesis).

All the regression analyses were modeled with negative binomial regression (Hilbe, 2007) using the glm.nb function from the MASS package (Venables & Ripley, 2002), version 7.3-47, in R, version 3.4. We specified a negative binomial regression model because the distributions of the outcomes appeared to follow an overdispersed count distribution (i.e., a peak frequency at or near the floor of each measurement, an exponentially decreasing frequency with higher scores, and variance greater than the mean). Given that the floor value for the STAI measure is 20, a constant of 20 was subtracted from STAI scores prior to fitting the model so that its floor would equal 0. Covariates were standardized prior to model fitting to facilitate interpretation of model coefficients as incident rate ratios (IRR), which are obtained by exponentiating the beta coefficients from the model. For history of MDD (a categorical covariate) the IRR corresponds to the percent change in the outcome for the RMD group relative to the HC group, holding other variables constant. For numerical covariates, the IRR corresponds to the percent change in the outcomes associated with a 1-standard-deviation (SD) increase in the covariate.

To provide a familiar index of goodness of fit and prediction, we computed an $R^2$ measure appropriate for negative binomial regression. (Cameron & Windmeijer, 1997) suggested an $R^2$ measure based on the ratio of Kullback-Leibler divergence between fitted and null models, which generalizes the "variance explained" interpretation of the traditional $R^2$ to one of "deviance explained". This is computed as 1 - dev/nulldev, where dev is the deviance of the fitted model and nulldev is the deviance of the intercept-only model. We refer to this statistic as $R_D^2$ or "deviance explained".

In addition, in order to address the current concerns about replicability in psychology (Aarts et al., 2015), we adopted a state-of-the-art analytical approach (i.e., k-fold cross-validation; James, Witten, Hastie, & Tibshirani, 2013) to ensure the trustworthiness and reliability of our findings. In detail, we computed a predictive $R_D^2$ using repeated 10-fold cross-validation (10-fold cross-validation repeated under 10 different randomizations). Similar to adjusted $R^2$, this statistic helps to identify model overfitting, but unlike adjusted $R^2$ (which applies a formulaic penalty for model complexity) predictive $R^2$ is empirically estimated by resampling the data and indicates the fraction of uncertainty in new data that the model is expected to explain. Functions used to calculate and cross-validate $R_D^2$ were written by one of the authors (JS) as part of an R package, available on the web at https://github.com/jashu/beset.

## Results

Descriptive statistics, t-tests, and correlations among temperamental and clinical variables split by group are reported in Table 1 (whole sample analysis is reported in Table S1). RMD individuals showed higher levels of depressive and anxiety symptoms than HC individuals. It is noteworthy, however, that both RMD and HC individuals reported symptoms whose average severity was below the clinical range (i.e., BDI-II < 14). ANT-indexes were largely independent, as reported in previous studies (Ishigami & Klein, 2010), with the exception of executive attention and orienting in the RMD sample (r = -.39) (MacLeod et al., 2010). Moreover, in keeping with Posner and colleagues (2002, note 1), effortful control was not related to executive attention, while it was related to both depressive and anxiety symptoms.

Table 2 (left-upper part) presents the results of negative binomial models with self-regulation processes and history of MDD predicting severity of depression in the whole sample. The analysis indicated strong, independent effects of a prior history of MDD and effortful control. Controlling for the other variables, RMD patients had about twice the number of current depressive symptoms as compared to healthy controls with no history of MDD, IRR = 2.07, 95% CI [1.59, 2.70], and a 1 SD increase in effortful control was associated with a 32% decrease in the number of depressive symptoms, IRR = 0.68, 95% CI [0.60, 0.77]. An additional, but weaker, effect was that a 1 SD increase in executive attention inefficiency predicted a 15% increase in depressive symptoms, IRR = 1.15, 95% CI [1.02, 1.32]. Alerting and orienting effects did not have a significant impact on the prediction of BDI-II. Interestingly, the model could account for about 19% of the deviance and cross-validation analysis confirmed that the model is likely to generalize to new data (i.e., predictive $R_D^2$ = 0.16).

Similarly, the analysis revealed that a prior history of MDD was associated with experiencing about one and a half times the number of anxiety symptoms, IRR = 1.41, 95% CI [1.20, 1.66], and a 1 SD increase in effortful control implied a 24% decrease in anxiety complaints, IRR = 0.76, 95% CI [0.71, 0.82]. No other predictor was statistically significant. It is noteworthy that the model could explain about 18% of the deviance, with a similar estimate being reported by the predictive model fit (i.e., predictive $R_D^2$ = 0.16). Note that all findings reported above were unchanged, when all the other temperamental variables (i.e., ATQ subscales) were introduced as covariates in the regression models (see Table S2).

In sum, the analysis revealed that, regardless of clinical status, lower levels of effortful control were markedly associated with more depressive and anxiety symptoms. Moreover, less efficient executive attention was associated with increased depressive complaints.

When compared to HC participants, RMD individuals did not report lower levels of effortful control or less efficient attentional mechanisms (all p's > 0.115; Table 1). Besides, no evidence was found that self-regulation processes were more tightly linked with either depression or anxiety in RMD participants than HC individuals (left-lower part and right-lower part of Table 2). It is worth stressing that adding the moderation effects in either model did not equate to an increase in the amount of deviance explained (i.e., 19% in both models), but it led to a worsening of the predictive fit (i.e., 14% and 15%). This suggest that including the moderation effect introduced overfitting of the models.

In sum, impaired effortful control was reliably associated with more depressive and anxiety symptoms. This held in the general population, regardless of clinical status (i.e., RMD VS. HC). Moreover, less efficient executive attention was specifically, but modestly, related to more depressive symptoms in the whole sample. No evidence was found that RMD individuals show less efficient self-regulation (i.e., mean-level difference) or a tighter link of effortful control and attentional mechanisms with symptoms (i.e., regression slope difference).

## Discussion

Temperamental effortful control and attentional networks are increasingly considered as crucial factors for mental health (Rothbart, 2007). Despite their influence on coping and emotion regulation (Rothbart et al., 2014; Rueda & Rothbart, 2009), the role of self-regulatory mechanisms in (remitted) adult depression is still unexplored. Hence, the main objective of our cross-sectional study was to investigate the impact of effortful control and attentional networks on depression and anxiety symptoms in community-representative samples of healthy and remitted depressed individuals.

Our results show that lower levels of effortful control substantially contributed to explaining the number of depressive symptoms and anxiety symptoms in the whole sample. In keeping with previous literature on children and adolescents (Laceulle et al., 2014; Verstraeten et al., 2009), this finding indicates that effortful control extends its influence to adult life and, importantly, it could function as a major transdiagnostic mechanism for internalizing disorders. Besides, as effortful control refers to the ability to instantiate top-down control in real life situations (i.e., "I can keep performing a task even when I would rather not do it" or "When interrupted or distracted, I usually can easily shift my attention back to whatever I was doing before"; Evans & Rothbart, 2007), our study stresses the importance of considering efficient self-regulation in naturalistic settings.

Our study also revealed that executive attention could account for depressive symptoms in the whole sample, but only to a modest extent, whereas alerting and orienting did not emerge as significant predictors. Moreover, no significant effect was detected for anxiety symptoms. Although the findings with regard to executive attention are promising, they should be considered with caution. On the one hand, the literature has previously acknowledged its role in depression, with less efficient executive attention being linked with prolonged time to remission of late-life depression (Murphy & Alexopoulos, 2006). On the other hand, however, the reported effect is fairly small and present only in the whole sample, whereas no significant association was found when the two subsamples were considered separately. Hence, more research on the role of executive attention is warranted to shed light on the role of this specific mechanism in depression.

No evidence was found that attentional networks and self-regulation are specifically impaired after remission from a depressive episode (i.e., mean-level difference hypothesis). In fact, the RMD and HC samples did not differ with respect to either effortful control or ANT indexes. This finding is in contrast with a recent study (Kanske et al., 2012), where RMD patients showed significantly less effortful control than HC individuals. It is noteworthy, however, that Kanske and colleagues' sample was small (i.e., 23 RMD patients and 25 HC individuals) and was not recruited to be representative in terms of age and socioeconomic status (Nooner et al., 2012). Hence, we believe our findings are to be taken as more representative and generalizable.

Moreover, the analysis did not reveal significant moderations of clinical status with any of the self-regulatory mechanisms investigated (i.e., regression slope difference hypothesis). Hence, having previously experienced a major clinical depression did not lead to a tighter association of effortful control or ANT-related indexes to symptoms. This finding appears to be in line with previous research showing that, although temperament can change through maturation (Caspi, Roberts, & Shiner, 2005) or in reaction to (extremely) adverse life events (Lockenhoff, Terracciano, Patriciu, Eaton, & Costa, 2009), a major depressive episode does not alter temperamental self-regulation in a permanent manner (Klein, Kotov, & Bufferd, 2011). Interestingly, our findings are also supportive of the continuity hypothesis in depression (Flett, Vredenburg, & Krames, 1997 ), according to which the various stages of the depressive trajectory (e.g., subclinical, fully clinical, and remitted depression) lie on a continuum and no qualitative differences among them are present. In keeping with this hypothesis, our study showed that the temperamental profile of healthy individuals mirrors that of remitted depressed patients. Future studies should further test this hypothesis, by investigating the role of temperamental self-regulation in MDD patients.

The current findings represent an initial step towards establishing the importance of temperamental effortful control and attentional mechanisms in the context of affective disorders. In light of our results, broader implications can be derived. Effortful control emerged as an important predictor of both depressive and anxiety symptoms, where it is noteworthy that specific clinical interventions could directly target this mechanism. A promising intervention may be Cognitive Control Training (CCT; Siegle, Ghinassi, & Thase, 2007), where, by means of a modified adaptive Paced Auditory Serial Addition Task (PASAT), the individual's ability to stay goal-focused while constantly processing new information is improved. Interestingly, CCT has proven effective in improving cognitive control and decreasing both depressive symptoms and rumination in at-risk and RMD individuals (Koster, Hoorelbeke, Onraedt, Owens, & Derakshan, 2017). Other promising interventions aimed at improving executive attention are attention trainings and attention state trainings (Tang & Posner, 2009). While the former group of training includes tasks that practice use of attentional networks, the latter group mostly consists of integrative body-mind training and mindfulness. There is preliminary evidence showing that both types of intervention can substantially improve children's executive attention and self-regulation, but research in adults is sparse (Tang & Posner, 2009).

This study has several strengths. First, our study examined the role of temperamental self-regulation in adults in a multi-method manner, by means of both well-validated self-report questionnaires and experimental paradigms. Previous studies usually conducted a more restricted assessment of temperamental self-regulation (Kanske et al., 2012; Murphy & Alexopoulos, 2006). Second, the present findings are likely generalizable, as the enhanced Nathan Kline Institute-Rockland sample is highly representative of the US adult population (Nooner et al., 2012). Third, in order to ensure the trustworthiness of our results, we adopted state-of-the-arte analytical techniques (i.e., k-fold cross-validation) to critically assess model overfitting and the reliability of our analyses.

In terms of limitations, the cross-sectional nature of our study does not allow disentangling whether inefficient self-regulation represents a precursor, a concomitant, or an output feature of depressive and anxiety symptoms. Albeit legitimate, this concern is mitigated by previous evidence showing the predictive power of effortful control with respect to internalizing disorders and, specifically, to major depression (Laceulle et al., 2014). Moreover, a recent theoretical review stresses that a construct closely related to temperamental self-regulation, such as cognitive control, is an important vulnerability factor to depression, although not necessarily a stable trait and likely to vary with changing levels of motivation or willingness to exert effort (Grahek, Everaert, Krebs, & Koster, in press). Hence, future studies should address the vulnerability role of inefficient self-regulation in adults with prospective research designs. Furthermore, no quantitative information about the inter-rater reliability was available, in that conflicting conclusions about the diagnostic status were reconciled by discussion with a senior SCID interviewer. Finally, in our study, we did not investigate the (potentially) different role of effortful control and attentional networks in MDD patients, hence it is unwarranted to extend our findings to individuals with full-blown depressive disorder.

In conclusion, our study suggests that temperament is likely to extend its influence on mental health well beyond childhood and adolescence and into full adulthood. In particular, effortful control and perhaps executive attention may be promising targets for better understanding vulnerability to (recurrent) depressive and anxiety symptoms in adults (Compas et al., 2004; Laceulle et al., 2014).

**Footnote**

[1]: All the analyses reported did not change, after excluding the individuals of the HC group who were taking antidepressant and/or anxiolytic medication.

**Figure caption**

**Figure 1.** The Attention Network Task (ANT) parameters, in accordance with Fan and colleagues (2002).

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**Table 1. Means, standard deviations, t-test, Cohen's d, and correlations by group (RMD = 90 and HC = 270)**

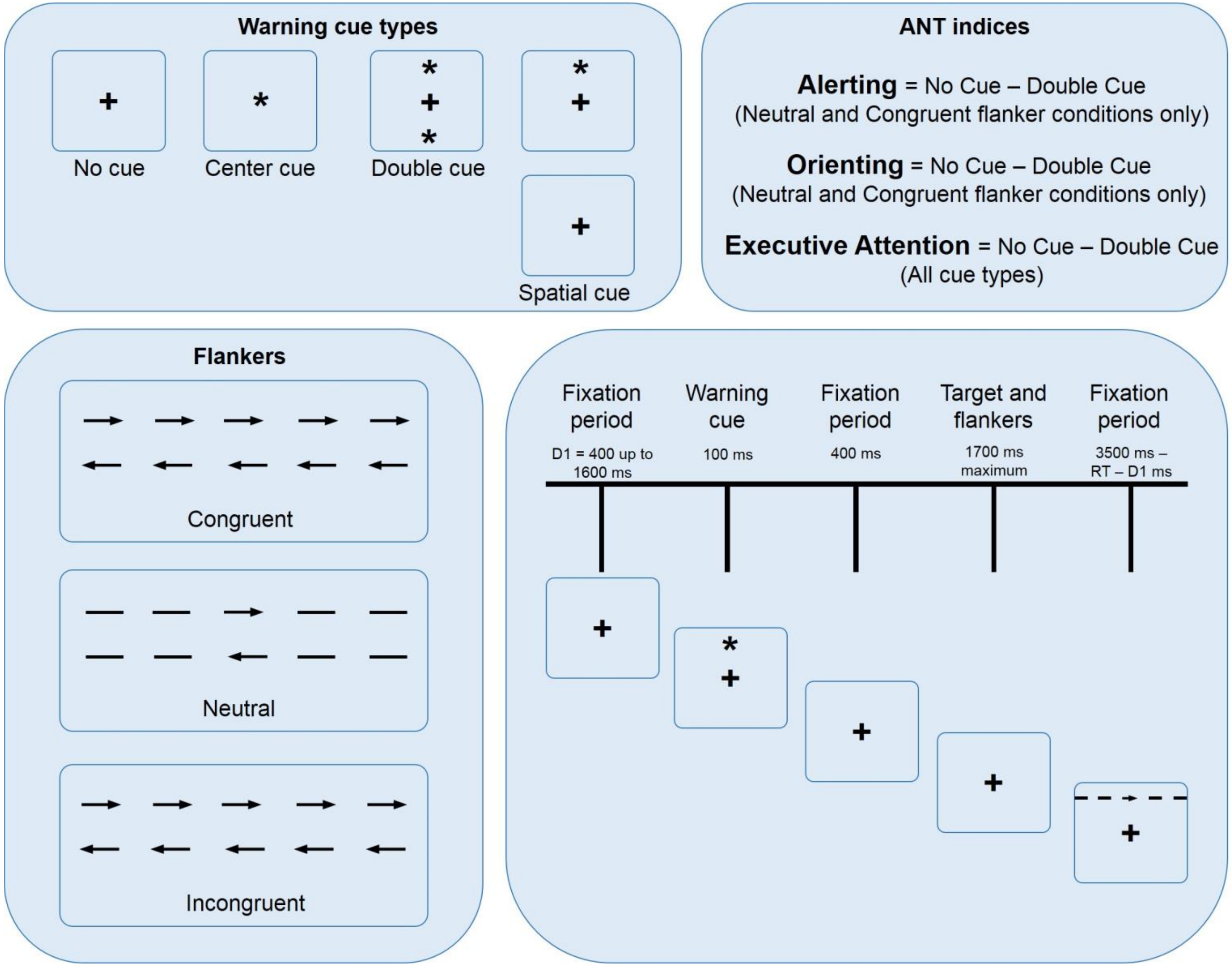
| Variable | RMD | | HC | | Group comparison | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | | | | | | | |
| 1. Effortful control (ATQ-EF) | 4.83 | 0.73 | 4.97 | 0.69 | t = 1.58, $p$ = 0.116, d = 0.20 | | -.00 | .07 | -.02 | -.28** | -.36** |
| 2. Alerting effect | 36.21 | 30.90 | 35.99 | 34.15 | t = 0.06, $p$ = 0.953, d = 0.01 | -.19 | | .09 | .14* | -.00 | -.02 |
| 3. Orienting effect | 15.26 | 22.76 | 18.56 | 22.19 | t = 1.20, $p$ = 0.232, d = 0.15 | -.02 | -.06 | | -.03 | .07 | .03 |
| 4. Conflict effect | 118.31 | 54.65 | 116.87 | 64.53 | t = 0.21, $p$ = 0.836, d = 0.03 | -.00 | .19 | -.39** | | .12 | .10 |
| 5. Depressive symptoms (BDI-II) | 8.67 | 8.49 | 3.70 | 4.33 | t = 5.32, $p$ < 0.001, d = 0.59 | -.49** | .07 | .04 | .18 | | .50** |
| 6. Anxiety symptoms (STAI) | 39.51 | 11.80 | 32.77 | 8.49 | t = 5.00, $p$ < 0.001, d = 0.57 | -.54** | -.01 | -.05 | .05 | .71** | |

*Note.* * indicates $p < .05$; ** indicates $p < .01$. *M* and *SD* are used to represent mean and standard deviation, respectively. RMD group correlations are reported under the diagonal and HC group correlations are reported above the diagonal.

**Table 2. Regression models with effortful control and ANT-related indexes predicting depressive symptoms and anxiety symptoms in the whole sample (n = 360)**

| | *Depressive Symptoms (BDI-II)* | | | | | *Anxiety Symptoms (STAI)* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variable | IRR | 95% CI [LL, UL] | *z* | *p* | $R_D^2$ ($predictive\ R_D^2$) | IRR | 95% CI [LL, UL] | *z* | *p* | $R_D^2$ ($predictive\ R_D^2$) |
| MDD History | 2.07 | [1.59, 2.70] | 5.45 | < .001 | | 1.41 | [1.20, 1.66] | 4.25 | < .001 | |
| ATQ-EF | 0.68 | [0.60, 0.77] | -6.42 | < .001 | | 0.76 | [0.71, 0.82] | -7.60 | < .001 | |
| Alert Effect | 0.93 | [0.83, 1.06] | -1.12 | 0.26 | | 0.96 | [0.89, 1.03] | -1.07 | 0.28 | |
| Orienting Effect | 1.07 | [0.93, 1.22] | 1.17 | 0.24 | | 1.01 | [0.93, 1.10] | 0.23 | 0.82 | |
| Executive Attention | 1.15 | [1.02, 1.32] | 2.43 | 0.02 | 0.19 (0.16) | 1.05 | [0.98, 1.13] | 1.49 | 0.14 | 0.18 (0.16) |
| | *Depressive Symptoms (BDI-II)* | | | | | *Anxiety Symptoms (STAI)* | | | | |
| Variable | IRR | 95% CI [LL, UL] | *z* | *p* | $R_D^2$ ($predictive\ R_D^2$) | IRR | 95% CI [LL, UL] | *z* | *p* | $R_D^2$ ($predictive\ R_D^2$) |
| MDD History | 1.97 | [1.51, 2.58] | 5.01 | < .001 | | 1.36 | [1.16, 1.60] | 3.79 | < .001 | |
| ATQ-EF | 0.71 | [0.62, 0.82] | -4.74 | < .001 | | 0.78 | [0.72, 0.85] | -5.79 | < .001 | |
| Alert Effect | 0.94 | [0.81, 1.08] | -0.92 | 0.36 | | 0.97 | [0.89, 1.05] | -0.67 | 0.50 | |
| Orienting Effect | 1.10 | [0.95, 1.28] | 1.34 | 0.18 | | 1.04 | [0.94, 1.15] | 0.76 | 0.45 | |
| Executive Attention | 1.12 | [0.97, 1.31] | 1.79 | 0.07 | | 1.06 | [0.98, 1.14] | 1.38 | 0.17 | |
| MDD Hist. × ATQ-EF | 0.82 | [0.62, 1.08] | -1.44 | 0.15 | | 0.87 | [0.74, 1.03] | -1.71 | 0.09 | |
| MDD Hist. × Alert | 0.98 | [0.74, 1.32] | -0.11 | 0.91 | | 0.94 | [0.80, 1.11] | -0.72 | 0.47 | |
| MDD Hist. × Orient | 0.91 | [0.66, 1.25] | -0.69 | 0.49 | | 0.88 | [0.73, 1.07] | -1.26 | 0.21 | |
| MDD Hist. × Exec Att | 1.09 | [0.80, 1.51] | 0.57 | 0.57 | 0.19 (0.14) | 0.97 | [0.81, 1.17] | -0.31 | 0.75 | 0.19 (0.15) |

**Figure 1.**



Warning cue types
+
*
*
+
*
*
+
+
No cue
Center cue
Double cue
Spatial cue
ANT indices
Alerting = No Cue – Double Cue
(Neutral and Congruent flanker conditions only)
Orienting = No Cue – Double Cue
(Neutral and Congruent flanker conditions only)
Executive Attention = No Cue – Double Cue
(All cue types)
Flankers
Congruent
Neutral
Incongruent
Fixation period
D1 = 400 up to 1600 ms
Warning cue
100 ms
Fixation period
400 ms
Target and flankers
1700 ms maximum
Fixation period
3500 ms – RT – D1 ms

**Supplementary Material**

**Table S1. Means, standard deviations, and correlations (whole sample, n = 360)**

| Variable | *M* | *SD* | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| 1. Effortful control (ATQ-EF) | 4.93 | 0.70 | | | | | |
| 2. Alerting effect | 36.04 | 33.32 | -.05 | | | | |
| 3. Orienting effect | 17.74 | 22.35 | .05 | .06 | | | |
| 4.Executive Attention | 117.23 | 62.14 | -.02 | .15** | -.11* | | |
| 5. Depressive symptoms (BDI-II) | 4.94 | 6.05 | -.35** | .02 | .03 | .12* | |
| 6. Anxiety symptoms (STAI) | 34.46 | 9.85 | -.42** | -.01 | -.01 | .08 | .63** |

*Note*. * indicates $p < .05$; ** indicates $p < .01$. *M* and *SD* are used to represent mean and standard deviation, respectively.

**Table S2. Regression models with ATQ subscales and ANT-related indexes predicting depressive symptoms and anxiety symptoms in the whole sample**

| | *Depressive Symptoms (BDI-II)* | | | | | *Anxiety Symptoms (STAI)* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variable | IRR | 95% CI [LL, UL] | *z* | *p* | $R_D^2$ ($predictive\ R_D^2$) | IRR | 95% CI [LL, UL] | *z* | *p* | $R_D^2$ ($predictive\ R_D^2$) |
| MDD History | 1.77 | [1.37, 2.29] | 4.39 | <.001 | | 1.25 | [1.07, 1.46] | 2.89 | 0.004 | |
| ATQ-EF | 0.78 | [0.69, 0.88] | -3.91 | < .001 | | 0.83 | [0.77, 0.89] | -5.04 | < .001 | |
| Alert Effect | 0.92 | [0.82, 1.04] | -1.33 | 0.18 | | 0.97 | [0.91, 1.04] | -0.88 | 0.38 | |
| Orienting Effect | 1.06 | [0.93, 1.20] | 0.99 | 0.32 | | 1.00 | [0.93, 1.07] | -0.03 | 0.97 | |
| Executive Attention | 1.14 | [1.01, 1.29] | 2.26 | 0.02 | | 1.05 | [0.99, 1.12] | 1.53 | 0.13 | |
| Negative Affect | 1.38 | [1.20, 1.60] | 4.57 | < .001 | | 1.25 | [1.15, 1.35] | 5.31 | < .001 | |
| Extraversion-Surgency | 0.88 | [0.78, 1.00] | -1.99 | 0.047 | | 0.89 | [0.83, 0.96] | -3.06 | 0.002 | |
| Orienting Sensitivity | 0.99 | [0.88, 1.12] | -0.10 | 0.92 | 0.25 (0.21) | 0.99 | [0.92, 1.07] | -0.18 | 0.85 | 0.28 (0.25) |

| | *Depressive Symptoms (BDI-II)* | | | | | *Anxiety Symptoms (STAI)* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variable | IRR | 95% CI [LL, UL] | *z* | *p* | $R_D^2$ ($predictive\ R_D^2$) | IRR | 95% CI [LL, UL] | *z* | *P* | $R_D^2$ ($predictive\ R_D^2$) |
| MDD History | 1.71 | [1.31, 2.24] | 3.94 | < .001 | | 1.22 | [ 1.04, 1.43] | 2.45 | 0.014 | |
| ATQ-EF | 0.80 | [0.69, 0.93] | -2.94 | 0.003 | | 0.83 | [0.77, 0.91] | -4.18 | < .001 | |
| Alert Effect | 0.91 | [0.80, 1.05] | -1.28 | 0.20 | | 0.98 | [0.91, 1.06] | -0.54 | 0.59 | |
| Orienting Effect | 1.09 | [0.94, 1.26] | 1.26 | 0.21 | | 1.02 | [0.94, 1.11] | 0.59 | 0.55 | |
| Executive Attention | 1.08 | [0.94, 1.24] | 1.19 | 0.23 | | 1.05 | [0.98, 1.12] | 1.22 | 0.22 | |
| Negative Affect | 1.36 | [1.14, 1.62] | 3.66 | < .001 | | 1.23 | [1.11, 1.34] | 4.17 | < .001 | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Extraversion-Surgency | 0.87 | [0.75, 1.00] | -1.99 | 0.046 | | 0.90 | [0.83, 0.98] | -2.44 | 0.14 | |
| Orienting Sensitivity | 1.03 | [0.89, 1.19] | 0.42 | 0.67 | | 1.00 | [0.92, 1.09] | 0.01 | 0.99 | |
| MDD Hist. x ATQ-EF | 0.88 | [0.66, 1.17] | -0.82 | 0.41 | | 0.95 | [0.80, 1.13] | -0.55 | 0.58 | |
| MDD Hist. x Alert | 1.02 | [0.78, 1.34] | 0.16 | 0.87 | | 0.95 | [0.82, 1.11] | -0.61 | 0.54 | |
| MDD Hist. x Orient. | 0.94 | [0.70, 1.26] | -0.43 | 0.66 | | 0.91 | [0.77, 1.07] | -1.15 | 0.25 | |
| MDD Hist. x Exec. | 1.21 | [0.9, 1.63] | 1.28 | 0.20 | | 1.01 | [0.85, 1.20] | 0.14 | 0.89 | |
| MDD Hist. x Neg. Aff. | 1.06 | [0.78, 1.45] | 0.40 | 0.69 | | 1.04 | [0.87, 1.25] | 0.45 | 0.65 | |
| MDD Hist. x Extrav. | 1.05 | [0.77 1.42] | 0.35 | 0.72 | | 0.95 | [0.80, 1.13] | -0.55 | 0.58 | |
| MDD Hist. x Orient. Sens. | 0.87 | [0.66, 1.14] | -1.00 | 0.32 | 0.26 (0.18) | 0.96 | [0.82. 1.13] | -0.45 | 0.65 | 0.29 (0.23) |

Note: n = 359, after list-wise deletion