Hedonic Orientation Moderates the Association Between Cognitive Control and Affect Reactivity to Daily Hassles in Adolescent Boys

Kathrin Klipker[1], Cornelia Wrzus[12], Antje Rauers[1], & Michaela Riediger[1]

[1]Max Planck Institute for Human Development, Berlin, Germany [2]Johannes-Gutenberg University Mainz, Mainz, Germany

This is a pre-copyedited, author-produced version of an article accepted for publication in *Emotion* following peer review. The version of record

Klipker, K., Wrzus, C., Rauers, A., & Riediger, M. (2017). Hedonic orientation moderates the association between cognitive control and affect reactivity to daily hassles in adolescent boys. Emotion, 17, 497-508. doi: 10.1037/emo0000241

is available online at: https://doi.org/10.1037/emo0000241.

Author Note

Kathrin Klipker, Max Planck Research Group “Affect Across the Lifespan“, Max Planck Institute (MPI) for Human Development, Berlin, Germany. Cornelia Wrzus, Max Planck Research Group “Affect Across the Lifespan“, MPI for Human Development, Berlin, Germany; Johannes-Gutenberg University Mainz, Mainz, Germany. Antje Rauers, and Michaela Riediger, Max Planck Research Group “Affect Across the Lifespan“, MPI for Human Development, Berlin, Germany.

Kathrin Klipker is now at Robert Koch Institute, Berlin, Germany; Cornelia Wrzus is now at Johannes-Gutenberg University Mainz, Germany; Antje Rauers and Michaela Riediger are now at the Heisenberg Research Group Socio-emotional Development and Health Across the Lifespan, Freie University of Berlin and Max Planck Institute for Human Development, Berlin, Germany.

Correspondence concerning this article should be addressed to Kathrin Klipker, Robert Koch Institute, Unit Mental Health, General-Pape-Str. 66, 12101 Berlin, Germany, E-mail: klipkerk@rki.de

Abstract

People often seek to regulate their affective reactions when confronted with hassles. Hassle reactivity is lower for people with higher cognitive control, presumably because of better affect regulation. Many adolescents, however, show higher hassle reactivity than children, despite better cognitive control. The present study aims to understand whether motivational differences when seeking to regulate affective experiences moderate the association between cognitive control and hassle reactivity in adolescence. We hypothesized that higher cognitive control is related to lower hassle reactivity only for adolescents with a strong hedonic orientation, that is, for adolescents who seek to maintain or enhance positive or to dampen negative affect. We investigated 149 boys' (10 - 20 years) hedonic orientation and affect reactivity towards daily hassles during two weeks of experience sampling. Higher cognitive control, assessed with a working-memory battery in the laboratory, was associated with stronger hassle reactivity in individuals with low hedonic orientation. The more hedonic-oriented individuals were, the lower was their hassle reactivity, but only in combination with high cognitive control. Our findings illustrate that higher cognitive control is not always related to lower hassle reactivity. Rather, when daily hassles compromise affect balance, hedonic orientation is equally important to understand affect reactivity in adolescent boys.

Keywords: affect reactivity, cognitive control, affect-regulation motivation, daily hassles and uplifts, adolescence

Hedonic Orientation Moderates the Association Between Cognitive Control and Affect Reactivity to Daily Hassles in Adolescent Boys

Unpleasant events, such as daily hassles, often initiate spontaneous affect-regulation attempts (e.g., Egloff, Schmukle, Burns, & Schwerdtfeger, 2006; Schmeichel & Demaree, 2010) because positive affective experiences are typically preferred to negative affective experiences accompanying hassles (e.g., Diener, 2000; Tsai, Knutson, & Fung, 2006). Among adults with better as compared to lower cognitive control, these negative affect reactions to hassles are less pronounced (e.g., Compton et al., 2008; Schmeichel & Demaree, 2010), presumably because cognitive control is a central component for affect regulation (e.g., Gray & Braver, 2007; Inzlicht, Bartholow, & Hirsh, 2015). Although cognitive control increases from childhood to late adolescence (e.g., Best & Miller, 2010), many adolescents show more negative affect reactions than children do (e.g., Larson, Moneta, Richards, & Wilson, 2002; Silk, Steinberg, & Morris, 2003).

With the current study, we aimed to contribute to a better understanding of why the age-related increase in cognitive control does not necessarily result in less pronounced negative affect reactions for adolescents. We approached this question by investigating the role of adolescents' desired affective states, which can vary in their hedonic orientation (e.g., Riediger, Schmiedek, Wagner, & Lindenberger, 2009; Tamir & Ford, 2012; Wood, Heimpel, Manwell, & Whittington, 2009). Hedonic orientation refers to people's tendency to seek to maintain or enhance positive, and to dampen negative affect (e.g., Mauss & Tamir, 2014; Riediger, Wrzus, & Wagner, 2014). For individuals with relatively high hedonic orientation, the occurrence of hassles likely initiates affect-regulation attempts because it induces a high discrepancy between their desired affective states and the event-provoking negative affect (e.g., Baumeister &

Eatherton, 1996; Mauss & Tamir, 2014). We therefore hypothesized that higher cognitive control is associated with lower negative affect reactivity to daily hassles only in adolescents with high, but not with low, hedonic orientation. In the following, we first review the available literature on the association between cognitive control and affect reactivity. Then, we discuss the role that hedonic orientation might play in the relationship between cognitive control and affect reactivity.

Cognitive Control and Affect Reactivity

People often influence the quality, intensity, timing, and dynamic features of affective experiences when they perceive discrepancies between their current and desired affective experiences (Kuppens & Verduyn, 2015; Gross & Thompson, 2007; Mauss & Tamir, 2014). Affect regulation can involve a series of cognitive processes that show considerable overlap with the concept of cognitive control, such as attentional deployment, cognitive disengagement, or behavioral inhibition (e.g., Mauss, Bunge, & Gross, 2007). Cognitive control encompasses those cognitive processes that underlie goal-directed behavior (e.g., regulating one's affective experiences), such as the ability to develop and carry out plans of action, to resist distraction or interference, and to update goals (e.g., Gray & Braver, 2007; Miller & Cohen, 2001; Olson & Luciana, 2008).

Different abilities, subsumed under the construct cognitive control, have been related to lower negative affect, for example lower extent of depressive symptoms (Robinson, 2007), less occurrence of daily negative affect (Rickenbach, Condeelis, & Haley, 2015), lower intensity of daily feelings of anxiety and anger in response to stressors (Compton et al., 2008; Sprague, Verona, Kalkhoff, & Kilmer, 2011), less variability in daily anger ratings (Hoeksma, Oosterlaan, & Schipper, 2004), less negative affect reactivity to negative laboratory stimuli (Compton, 2000), and higher ability to regulate affective experiences in response to a stressful task

(Johnson, 2009). Working memory is a central component of cognitive control (e.g., Engle, Kane, & Tuholski, 1999; Gray & Braver, 2007; Schleepen & Jonkman, 2010) and commonly defined as the ability to temporarily store and manipulate information in memory. Of cognitive control functions, particularly working memory was related to better regulation, lower experience, and lower expression of negative affective experiences in previous studies (Pe, Raes, & Kuppens, 2015; Schmeichel & Demaree, 2010; Schmeichel, Volokhov, & Demaree, 2008; Schweizer, Grahn, Hampshire, Mobbs, & Dalgleish, 2013). Taken together, these studies showed that negative affect reactivity was lower for individuals with higher levels of cognitive control. A few studies also linked higher cognitive control to higher levels of positive affect (Rickenbach et al., 2015; Robinson, 2007). Overall, however, people seem to initiate affect regulation more so in response to unpleasant than to pleasant events (e.g., Volokhof & Demaree, 2010), making the down-regulation of negative affect the most common affect-regulation attempt (see Gross, 2014).

Because cognitive control shows substantial development throughout childhood and adolescence (for reviews, see Best & Miller, 2010; Luna, 2009), one would expect lower negative affect reactivity as children get older. In contrast, prior studies showed that, on average, affective reactions in adolescence were more negative than affective reactions in late childhood (e.g., Larson et al., 2002; Silk et al., 2003). These findings are complemented by inconsistent results on the development of affect-regulation skills throughout adolescence. Some studies report on average more frequent or efficient affect regulation in adolescence as compared to late childhood, while others found affect regulation to be less frequent or less efficient in this age group (for reviews see Riediger & Klipker, 2014; Zimmermann & Iwanski, 2014).

It has been argued that cognitive control is involved in better affect-regulation abilities because individuals might be able to use more effective affect-regulation strategies, such as reappraisal (e.g., Aldwin, Yancura, & Boeninger, 2010). However, other studies found that affect-regulation success was related to cognitive control irrespective of the affect-regulation strategy people applied (e.g., Pe, Raes, Koval, Brans, Verduyn, & Kuppens, 2013). To date, the available evidence on the use of affect-regulation strategies in adolescence is highly inconsistent (for reviews see Riediger & Klipker, 2014; Zimmermann & Iwanski, 2014), which impedes definite conclusions on the role affect-regulation strategies might play in the association between adolescents' developing cognitive control and their negative affect reactivity. Nevertheless, both lower affect-regulation skills and higher negative affect reactivity in adolescence as compared to late childhood are puzzling in light of increasing cognitive-control capacities with age. In the current study, we hypothesized that individual differences in hedonic orientation moderate the association between cognitive control and negative affect reactivity in adolescence.

The Role of Hedonic Orientation in Affect Reactivity

Individuals are able to change their affective reactions by altering the quality, intensity, and duration of affective experiences. Whether affective experiences are diminished or amplified is determined by an individual's desired affective state (e.g., Gross, 2014; Riediger, 2015). Most affect-regulation attempts are hedonic-oriented, that is, motivated by the wish to maintain or increase well-being (e.g., Larsen, 2000; Mauss & Tamir, 2014; Riediger et al., 2009; Riediger et al., 2014). Others however, are motivated by the wish to dwell on or increase negative, or to dampen positive affect (for discussion of reasons, see Parrott, 1993; Tamir, Mitchell, & Gross, 2008). Research has revealed pronounced inter-individual differences in the extent of people's hedonic orientation. There is, for example, evidence of an age-related increase in hedonic orientation from adolescence to old age (Riediger et al., 2009; Riediger et al., 2014). Individual differences in hedonic orientation have also been related to personal dispositions, such as self-esteem (e.g., Heimpel, Wood, Marshall, & Brown, 2002; Wood et al., 2009). To date, these individual differences in hedonic orientation, however, have largely been neglected in research on affect reactivity (for an overview, see Mauss & Tamir, 2014). By directly addressing individual differences in hedonic orientations in a sample spanning from late childhood to early adulthood, we aim to contribute to a better understanding of why higher cognitive control does not necessarily result in lower negative affect reactivity to daily hassles.

The Current Study

We hypothesized that when confronted with hassles, individuals show lower negative affect reactivity only when they have high cognitive control and high hedonic orientation. That is, we argue that individuals with low cognitive control might not be able to effectively down-regulate their negative affect, although they might want to. Furthermore, individuals with low hedonic orientation might not want to down-regulate their negative affect, although they might be able to do so. To examine whether cognitive control and hedonic orientation specifically predict affect reactivity to daily hassles (i.e. unpleasant events), we additionally tested their effects on affect reactivity to daily uplifts (i.e. pleasant events) in control analyses. In the following we will use the terms hassle reactivity and uplift reactivity when referring to affect reactivity to daily hassles and uplifts, respectively. Given that people seem to initiate affect regulation more so in response to unpleasant than to pleasant events (e.g., Volokhof & Demaree, 2010), we expected the impact of hedonic orientation and cognitive control to be particularly pronounced for hassle reactivity and to be comparatively less evident in uplift reactivity.

We investigated our hypotheses using data from a larger project on the association between longitudinal changes in pubertal development and affective experiences of adolescent boys conducted in Berlin, Germany. All data reported were assessed at the second measurement wave of the study. Cognitive control was measured in the laboratory using a battery of working-memory tasks. Hedonic orientation and affective experiences were measured using experience-sampling methodology in adolescents' daily lives.

Method

Participants

We investigated a sample of 149 boys ranging in age from 10 to 20 years ($M = 15.36$; $SD = 2.66$) who were born and raised in Germany and who spoke German as their first language. Participants lived with both (69%) or one of their parents (31%) in Berlin, Germany. Of the participants, 95% attended school (grades 5 to 13), 4% attended college and 1% attended vocational training. Dependent on their current age, participants had 5 to 15 years of education ($M = 9.04$; $SD = 2.39$; $r_{age} = .96$, $p < .05$). Socio-economic status (income and education) was reported by 78% of the participants' parents. Of monthly family net incomes, 5% were below 1,250 Euros (i.e., 1,403 USD) and 5% were above 7,500 Euros (i.e., 8,417 USD), with 50% between 2,250 and 4,500 Euros (i.e., between 2,525 and 5,051 USD). Most parents were highly educated with 73% reporting that they have obtained a university degree, 11%, a university entrance diploma, and 16%, a high-school diploma as highest academic degree.

Procedure

Participants (and their legal guardians) provided their informed consent for the study and participated in a two-week experience-sampling phase and two laboratory sessions, one before and one after the experience-sampling phase. In each of the laboratory sessions, participants completed several questionnaires and working-memory tasks. In the first laboratory session, participants received detailed instructions on the subsequent experience-sampling phase.

The mobile-phone based experience-sampling phase comprised three cycles of three assessment days followed by two rest days each. Six times on each assessment day (randomized to occur approximately every two hours: $M = 2.00$, $SD = 0.50$), participants were prompted to answer several questions and to enter their responses by using the phone's joystick. First, they were asked to report on their momentary affective experiences with regard to several emotion adjectives. This was followed by questions on whether participants had experienced a recent hassle or uplift since the last assessment occasion. On average, participants indicated that they had experienced a recent hassle in 14.33 (31%) assessment occasions ($SD = 7.11$) and a recent uplift in 30.20 (66%) assessment occasions (SD = 10.11). One participant did not report any hassle and was thus not included in the analyses referring to hassle reactivity. For each assessment on which a hassle or uplift had occurred, participants specified the event and reported their event-related affect (i.e., how they had felt during the hassle/uplift). The assessment ended by prompting participants to report whether they wanted to influence their momentary affective experiences (see measurement of *Hedonic orientation*). Participants received a reimbursement of EUR 70 (USD 96) that was increased to EUR 80 (USD 109) if they had responded to more than 80% of assessments in the experience-sampling phase. The ethics committee of the Max Planck Institute for Human Development approved of the study prior to data collection.

Measures

Cognitive control (assessed in laboratory session 1 and 2). We programmed a battery of four computerized working-memory tasks that have been used with children and adults to assess individuals' cognitive control (e.g., Engle, 2010; Schleepen & Jonkman, 2010).

The Backward Corsi Block-Tapping Task (Corsi, 1972) and the Reading Span task (Daneman & Carpenter, 1980) were used to measure participants' visuo-spatial and verbal complex working-memory span. In both tasks, an increasing sequence of (visuo-spatial and verbal) stimuli was presented on a computer screen and participants repeated the presented sequence afterwards in reverse order, following the standard protocol of the respective tasks. The longest correctly repeated sequences were used as measures of complex visuo-spatial and verbal working-memory span, respectively.

A figural version of the memory-updating task (Salthouse, Babock, & Shaw, 1991) and a column *N*-back task (Cohen et al., 1997) were used to measure participants' visuo-spatial and verbal working-memory updating. In the figural memory-updating task, participants remembered and mentally updated the spatial positions of several stimuli. Consecutively presented arrows indicated changes in the positions of the stimuli. All participants completed a total of 39 trials with three difficulty levels (difficulty 1: two stimuli and a total of three updating operations, difficulty 2: three stimuli and a total of two updating operations, difficulty 3: three stimuli and a total of three updating operations). Percentage of correct trial positions was used as a measure of visuo-spatial working-memory updating. In the column *N*-back task, we used two and three columns, representing a 2- and 3-back task, respectively. In accordance with the standard protocol of the column *N*-back task, participants indicated whether or not a stimulus appeared twice in a row in the same column. Both task versions consisted of 60 alphabetic characters (presentation time: 1 second, inter-stimulus interval: 1.4 seconds) of which one third were targets. Participants' mean accuracy of correctly identified alphabetic characters was used as a measure of verbal working-memory updating.

Working-memory tasks moderately correlated with each other (average $r = .35$). We *z*-standardized all visuo-spatial and verbal working-memory span and updating measures to yield individuals' average *z*-score measure of cognitive control, ranging from −2.08 to 1.38. Cognitive control was higher the older participants were ($\beta_{\text{age}} = 0.377$, $p < .05$; $\beta_{\text{age} \times \text{age}} = -0.151$, $p = .054$, adjusted $R^2 = 13.4\%$; $F(2,147) = 12.490$; $p < .05$).

Hedonic orientation (assessed during experience-sampling phase). On each assessment occasion of the experience-sampling phase, participants indicated whether they wanted to influence their current affect. For each of the four positive and four negative momentary affect adjectives (i.e., happy, enthusiastic, content, relaxed, angry, stressed, sad, disappointed) participants selected one of four answer categories, that is, either dampen, maintain, enhance, or not influence the respective momentary affect. For each assessment occasion, the relative frequency of responses when participants reported the wish to maintain or enhance positive feelings or the wish to dampen negative feelings served as momentary indicator for hedonic orientation. Relative frequencies of these momentary hedonic orientations were averaged across all measurement occasions to yield an indicator of participants' hedonic orientation. Hedonic orientation ranges theoretically from 0 (hedonic orientation was never reported) to 1 (hedonic orientation was always reported). Participants' reported hedonic orientation ranged from 0.01 to 0.98 ($M = 0.57$; $SD = 0.24$) and was not significantly predicted by participants' age ($\beta_{\text{age}} = -0.051$, $p = .546$; $\beta_{\text{age} \times \text{age}} = 0.007$, $p = .931$, adjusted $R^2 = < 0.1\%$; $F(2,146) = 0.183$, $p = .833$).

Affect reactivity (assessed during experience-sampling phase). At each assessment, participants rated their momentary affect with four negative (angry, stressed, sad, and disappointed) and four positive adjectives (happy, enthusiastic, content, and relaxed) and additionally indicated hassle or uplift occurrence (i.e. whether they had experienced a pleasant or unpleasant event) since the last assessment occasion. Participants specified the event (see *Covariates*) and reported their *hassle/uplift-related affect* (i.e., how they had felt during the hassle/uplift) using the same affect adjectives and 7-point Likert scale ranging from 0 (*not at all*) to 6 (*very much*) as for the momentary affect rating. To calculate participants' momentary *hassle reactivity*, we subtracted participants' *average level* of momentary negative affect (using the mean per assessment of angry, stressed, sad, and disappointed) across the entire experience-sampling phase from each of the *hassle-related* momentary affect ratings on the same affect adjectives. To calculate participants' momentary *uplift reactivity*, we subtracted participants' *average level* of momentary positive affect (using the mean per assessment of happy, enthusiastic, content, and relaxed) across the entire experience-sampling phase from each of the *uplift-related* momentary affect ratings on the same affect adjectives. Thus, hassle and uplift reactivity were operationalized as momentary deviations of participants' current negative and positive affect from their respective within-person averages.

Participants' hassle reactivity was larger than 0 in 89% of occasions, indicating that their negative affect towards hassles was higher than their average level of negative affect. Participants' hassle reactivity scores ranged from −2.19 to 5.47 (average within-person mean = 1.49; average within-person *SD* = 1.04). Participants' uplift reactivity was larger than 0 in 69% of occasions, indicating that their positive affect towards uplifts was higher than their average level of positive affect. Participants' uplift reactivity scores ranged from -4.53 to 4.06 (average within-person mean = 0.46; average within-person *SD* = 1.03).

Covariates: hassle/uplift characteristics (assessed during experience-sampling phase). For each assessment occasion on which a hassle or uplift was reported, participants also indicated how long ago it had occurred (for hassles: 64% had occurred less than 30 minutes ago, 16% less than one hour, and 20% less than two hours ago; for uplifts: 66% had occurred less than 30 minutes ago, 17% less than 1 hour, and 17% less than two hours ago) and how important the event was (ranging from 0 'not at all' to 6 'very much', for hassles: average within-person *M*

= 2.60, average within-person *SD* = 1.63; for uplifts: average within-person *M*= 2.40, average within-person *SD* = 1.53).

Covariates: habitual use of affect-regulation strategies (assessed in laboratory session 2). In the laboratory session following the experience sampling phase, participants filled out a translated version of the Emotion Regulation Questionnaire for Children and Adolescents (ERQ-CA; Gullone & Taffe, 2012). The ERQ-CA assesses participants' evaluations of their habitual use of two emotion-regulation strategies with four items reflecting emotional suppression (e.g., I control my feelings by not showing them) and six items reflecting emotional reappraisal (e.g., When I want to feel happier, I think about something different). Using a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree), participants indicated how well each of the statements applied to themselves. On average, participants showed moderate agreement with using reappraisal (M = 2.88; SD = 0.69) and suppression (M = 2.68, SD = 0.80) strategies to regulate their affective experiences. Use of affect-regulation strategies was not significantly predicted by participants' age (reappraisal: $\beta_{age} = 0.068$, $p = .416$; $\beta_{age \times age} = 0.079$, $p = .346$, adjusted $R^2 = < 0.1\%$; $F(2,145) = 0.945$, $p = .391$; suppression: $\beta_{age} = 0.124$, $p = .142$; $\beta_{age \times age} = 0.008$, $p = .924$, adjusted $R^2 = < 0.1\%$; $F(2,145) = 0.154$, $p = .318$).

Statistical Analyses

We used hierarchical linear modeling (HLM) to investigate how cognitive control and hedonic orientation (level 2: person) predicted hassle reactivity (or uplift reactivity, respectively, in control analyses; both level 1: measurement occasion). As opposed to traditional ordinary least squares regression, HLM accounts for within-person dependencies among repeated measurements of affect reactivity and varying numbers of repeated measurements per person. HLM adjusts standard errors and provides unbiased estimates of regression coefficients because coefficients can be viewed as weighted least squares estimators (e.g., Raudenbush & Bryk, 2002). Additionally, using HLM, level 1 covariates could be included to test whether model results were affected by within-person variations in event characteristics. All predictor variables were centered to the sample's mean. Hierarchical linear modeling was performed using the multilevel package in R (Bliese, 2013). Model fit significantly improved when we accounted for within-person dependencies as compared to when within-person dependencies were discarded, $\chi^2(1) = 377.77$, $p < .001$.

Results

We first investigated a potential interaction effect between cognitive control and hedonic orientation on hassle reactivity. We then followed up on this interaction by exploring the moderating role of hedonic orientation and cognitive control in more detail. In a last step, we controlled for potential effects of age (for possible effects of puberty, see *Supplementary material*), emotion-regulation strategies, and hassle characteristics. In a last step, we explored our assumption on the role of hedonic orientation and cognitive control in daily uplifts. Between-person zero-order correlations of all central variables are given in Table 1.

Interaction of Cognitive Control and Hedonic Orientation Predicted Hassle Reactivity

Results confirmed a significant interaction effect between hedonic orientation and cognitive control when predicting hassle reactivity. Main effects of cognitive control and hedonic orientation were not significant. The inclusion of the interaction effect in our model in addition to the two main effects increased the modeled between-person variance by 6.71% (representing proportional reduction in the level-2 residual variance in comparison with model with two main effects but without the interaction term; cf. Singer & Willett, 2003), indicating small effect size. Complete model results are given in Table 2 (Model 1). We followed up on this interaction in two ways: First, we investigated how hedonic orientation moderated the association between cognitive control and hassle reactivity. Second, we investigated how cognitive control moderated the association between hedonic orientation and hassle reactivity.

The moderating role of hedonic orientation. We plotted model-based predictions of the associations between cognitive control and hassle reactivity for different values of hedonic orientation using HLM interaction plots (Bauer & Curran, 2005). For individuals with low hedonic orientation, higher cognitive control was associated with more hassle reactivity (see positive slope of Figure 1). Hierarchical region of significant analysis (Bauer & Curran, 2005) indicated that the positive simple slope of cognitive control on hassle reactivity reached significance for individuals with hedonic orientations of less than .57 ($M + 0.04$ SD), that is for individuals that reported hedonic-oriented affect-regulation motivation for less than 57 % of their momentary affects over the two-week experience-sampling phase. This pertained to 46% of participants in our sample.

In a next step, we tried to better understand affect-regulation motivation of low-hedonic oriented individuals. We therefore tested whether individuals with low (as compared to high) hedonic orientation were less motivated to regulate their affect (operationalized in accordance with hedonic orientation: percentage of individuals' reports to not influence their positive or negative affect) or whether their affect-regulation motivation was more directed at decreasing well-being and thus contra-hedonic (operationalized in accordance with hedonic orientation: percentage of individuals' reports to maintain or increase their negative affect or to decrease their positive affect). Participants with low hedonic orientation (i.e., < .57) showed overall lower motivation to regulate their affect ($M = 0.47$, $SD = 0.29$) than individuals with high hedonic orientation ($M = 0.12$, $SD = 0.11$, Welch's independent sample t-test: $t(93) = 9.699$, $p < .05$).

Participants with low hedonic orientation did not report more contra-hedonic motivation (*M* = 0.10, *SD* = 0.13) than participants with higher hedonic orientation (*M* = 0.08, *SD* = 0.08, Welch's independent sample *t*-test: $t(118) = 1.103$, $p = .272$).

Figure 1 suggests a negative slope for individuals with high hedonic orientation. However, contrary to our expectations, simple slopes between between cognitive control and hassle reactivity did not reach significance for any value of hedonic orientation above .57.

The moderating role of cognitive control. We next investigated model-based predictions of the associations between hedonic orientation and hassle reactivity for different values of cognitive control. Again, we performed hierarchical region of significance analysis. Consistent with our assumption, higher hedonic orientation was related to lower hassle reactivity for individuals with cognitive control *z*-scores higher than 0.91 (*M* + 1.23 *SD*). The opposite simple slope was found for individuals with cognitive control *z*-scores lower than −0.36 (*M* - 0.57 *SD*). Model-based predictions are plotted in Figure 2.

Control Analyses

Participants' age. Our sample's age range spanned from late childhood to early adulthood. Because individuals in this age range differed in their affect reactivity in prior studies (e.g., Larson et al., 2002; Silk et al., 2003), we next controlled model results for participants' age. Participants' age did not predict hassle reactivity when included as a level 2 covariate in our model (Age: B= -0.095, SE = 0.098, p = .335; Age × Age: B = 0.005, SE = 0.008, p = 0.557) and the interaction effect between cognitive control and hedonic orientation remained significant. We also tested, whether age moderated the associations between hedonic orientation, cognitive control, and hassle reactivity, but that was not the case in any of the models (all *p*s > .224). For reasons of model parsimony, we did not include the nonsignificant quadratic age effect or the nonsignificant age interaction effects in the final model (see Table 2, Model 2).

In addition to adolescents' age, recent research highlights the role of adolescents' pubertal development in the context of cognitive and affective development (e.g., Crone & Dahl, 2012). Therefore, we additionally controlled analyses for individual differences in adolescents' pubertal development. We employed a separate set of analyses because of problems of collinearity between age and pubertal development. Model results with pubertal development as covariate paralleled results with chronological age as covariate (see *Supplementary material*).

Emotion-regulation strategies. Participants differed in their habitual use of two emotion-regulation strategies, reappraisal and suppression, which might have affected our results. We therefore included these variables as level 2 covariates in the final model. Habitual use of reappraisal or suppression as strategy for emotion regulation did not predict hassle reactivity. The cognitive control × hedonic orientation interaction remained significant after including reappraisal and suppression in the final model (Table 2, Model 2).

Hassle characteristics. Across measurement occasions, hassles differed in ratings of their importance and in the time that had passed between hassle occurrence and the affect rating towards the hassle. We therefore included these variables as level 1 covariates in the model. Results showed that more important hassles were associated with higher hassle reactivity (Table 2, Model 2). Also, participants' hassle reactivity was higher the more time had elapsed since the hassle had occurred. The inclusion of hassle importance and elapsed time since hassle occurrence (i.e., time lag) in the model did not affect the cognitive control × hedonic orientation interaction (see Table 2, Model 2).

The role of hedonic orientation and cognitive control in daily uplifts. Results showed two main effects of hedonic orientation and cognitive control when predicting uplift reactivity, but there was no significant interaction effect between cognitive control and hedonic orientation (Table 3, Model 1). That is, higher cognitive control was associated with higher uplift reactivity regardless of participants' hedonic orientation; and higher hedonic orientation was associated with higher uplift reactivity regardless of participants' cognitive control. Participants' age did not predict uplift reactivity when included in the model (Age: B= -0.107, SE = 0.070, p = .128; Age × Age: B = 0.008, SE = 0.006, p = 0.164). In addition, age did not significantly moderate the association between hedonic orientation, cognitive control, and uplift reactivity (all ps > .157).

Discussion

In the current study, we investigated the association between cognitive control and hassle reactivity in adolescence, by considering individual differences in hedonic orientation. We hypothesized that hedonic orientation and cognitive control interact in shaping adolescents' hassle reactivity. We expected to find that higher cognitive control is related to lower hassle reactivity only for individuals with a relatively strong hedonic motivation.

Cognitive Control, Hedonic Orientation, and Hassle Reactivity

In line with our hypothesis, adolescents' hedonic orientation and cognitive control interacted in predicting hassle reactivity. Results indicated that hedonic orientation moderated the association between cognitive control and hassle reactivity, and that cognitive control moderated the association between hedonic orientation and hassle reactivity. We will discuss these moderation effects in the following.

The role of hedonic orientation. Higher cognitive control was related to higher hassle reactivity for adolescents with low hedonic orientation. This was not the case for adolescents with high hedonic orientation. Low hedonic-oriented adolescents differed from high hedonic-orientated adolescents in that they more often reported not wanting to regulate their momentary affective experiences. This might reflect that cognitive control contributes to maintain and update information, that is, the hassle or the negative feelings, in memory, increasing hassle-related negative affect. This process might only be stopped when adolescents have a strong hedonic-orientated affect-regulation motivation. In that case, adolescents might use their cognitive- control capacity to decrease negative affect. For individuals without a strong hedonic orientation, however, cognitive control might contribute to an enhanced and extended attentional focus on negative feelings and negative aspects of the situation. This interpretation is in line with a recent extension of the multicomponent model of working memory proposing that affective experiences are held in working memory and that individuals' hedonic detector system guides attention towards or away from them (Baddeley, 2013).

This argumentation might partly explain why higher cognitive control was related to higher hassle reactivity for adolescents with comparably low, but not high hedonic orientation. However, based on prior studies on adults (e.g., Compton et al., 2008; Johnson, 2009; Schmeichel & Demaree, 2010), we had expected that for adolescents with relatively high hedonic orientation, higher cognitive control actually resulted in lower hassle reactivity by enabling individuals to decrease their negative affect. We might have not been able to replicate this association found in previous studies with adults because, unlike the relative stability of cognitive control in young and middle adulthood, cognitive control still develops in adolescence (for reviews, see Best & Miller, 2010; Luna, 2009). Thus, adolescents' cognitive control might not yet have reached values high enough to effectively decrease negative affect in response to hassles. Additionally, evidence on lower hassle reactivity in adults with relatively high cognitive control might partly reflect the influence of other factors, such as individual differences in the use of affect-regulation strategies. In line with Pe and colleagues (2013), we did not find that habitual use of two affect-regulation strategies (i.e., reappraisal and suppression) affected the association between cognitive control and hassle reactivity. Future studies are needed to investigate whether habitual use of other affect-regulation strategies, situational differences in use of affect-regulation strategies, or the initially inefficient use of newly acquired strategies partly explain why higher cognitive control did not predict lower hassle reactivity in the present study.

The role of cognitive control. We found that stronger hedonic orientation was associated with lower hassle reactivity for individuals with advanced cognitive control. Although it is difficult to disentangle affective reactions from affect regulation (Gross & Thompson, 2007; Gyurark, Gross, & Etkin, 2011), this effect is in accordance with our expectation that high cognitive control might help to down-regulate hassle reactivity the stronger individuals want to promote their well-being.

For individuals with less advanced cognitive control, we found the opposite effect: Higher hedonic orientation was related to higher hassle reactivity. This effect might reflect a conflict between an individual's strong hedonic orientation and their low cognitive ability to maintain well-being successfully in the presence of daily hassles. It is therefore likely that for individuals with high hedonic orientation and low cognitive control, hassles might pose a stronger concern. As a result, these individuals may appraise hassles as more unexpected and less controllable, which has been shown to be associated with stronger negative affect reactions in prior studies (e.g., Koolhaas et al., 2011; Maier & Watkins, 2005). However, this speculation warrants further empirical investigations in future studies.

As hassles have been shown to differ across adolescence (Byrne, Davenport, & Mazanov, 2007; Eccles, Templeton, Barber, & Stone, 2003; Ge, Lorenz, Conger, Elder, & Simons, 1994) and are likely to also differ across measurement occasions, we additionally investigated whether the association between cognitive control, hedonic orientation, and hassle reactivity was influenced by differences in the type of the reported hassles. Our results showed that participants rated their affective experiences towards hassles as more negative the more important the hassle was to them. Hassle reactivity also differed in the time-lag between occurrence and reporting. We found that our participants showed higher hassle reactivity the more time had passed since the hassle occurred. This might reflect a stronger memory and focus on negative affective material in adolescence that has been previously reported in the literature (Quevedo, Benning, Gunnar, & Dahl, 2009; Silk et al., 2009; Van Honk et al., 1999). Additionally, studies on the perception on past and future affective experiences show that individuals tend to overemphasize peaks of their experiences, which biases their memory of past experiences (e.g., Kahneman & Richard, 2006). However, the moderating role of hedonic orientation in the association between cognitive control and hassle reactivity remained stable after controlling for hassle importance and time-lag.

Uplift reactivity, hedonic orientation, and cognitive control. Cognitive control is primarily involved in regulating negative affective experiences accompanying unpleasant events, such as daily hassles. However, cognitive control has also been associated with higher positive affective experiences to pleasant events (e.g., Volokhof & Demaree, 2010; Rickenbach et al., 2015), such as daily uplifts. Consistent with previous evidence, our results showed that cognitive control contributed to higher uplift reactivity (i.e. positive affect in response to uplifts). In addition, our results showed that higher hedonic orientation was associated with higher uplift reactivity. We did not observe, however, that hedonic orientation moderated the association between cognitive control and uplift reactivity.

Although our results on hassle and uplift reactivity seem conflicting, they are both in accordance with our previous argumentation building on the model proposed by Baddeley (2013): With regard to hassles, cognitive control likely contributes to maintain and update the hassle and the hassle-related negative affect in memory. This process might only be stopped when adolescents have a conflicting affect-regulation motivation, that is, a strong hedonic orientation. With regard to uplifts, cognitive control likely contributes to maintain and update the uplift and the uplift-related positive affect in memory, which might only be stopped when adolescents have a strong contra-hedonic affect-regulation motivation. In this case, they might use their cognitive-control capacity to decrease their uplift-related positive affect. In the current study, adolescents with relatively low hedonic orientation did not report more contra-hedonic affect-regulation motivation, but rather no affect-regulation motivation. Therefore, cognitive control was likely not used to guide attention away from the uplift or uplift-related positive affect for both low and high hedonic-orientated adolescents. This might have impeded the finding of a moderating effect of hedonic orientation with regard to uplifts. In addition to the lack of a predominant contra-hedonic orientation, uplift-related positive affect was relatively low, that is, only slightly higher than individuals' average positive affect. It is possible that a high contra-hedonic orientation and the occurrence of events triggering more intense positive emotions than those observed in the current study are necessary to provoke a conflict with the desired affect. So far, these assumptions are speculative and need further investigation in future studies.

Strengths, Limitations, and Outlook

A strength of our study is the use of an extensive battery of different age-sensitive working-memory tasks with different material and several difficulty levels to avoid bottom or ceiling effects for children and adolescents. We thus optimized the validity in assessing working-memory capacity as a central component of cognitive control. This is a noteworthy strength as most prior studies only used one task to assess cognitive control when investigating the effect of cognitive-control functions on affective experiences (Compton, 2000, Schmeichel & Demanrre, 2010). An interesting task for future studies would be to disentangle the role of adolescents' cognitive-control capacity under relatively stable laboratory circumstances from adolescents' available cognitive control in emotionally challenging situations (see Prencipe, Kesek, Cohen, Lamm, Lewis, & Zelazo, 2010). Previous research has shown that the involvement of cognitive control in emotionally challenging situations is particularly affected by pubertal development (e.g., Crone & Dahl, 2012; Steinberg, 2005). Although including pubertal development as covariate in the analyses did not alter model results in our study (see *Supplementary material*), further consideration of the role of puberty, and inclusion of more refined measures to assess it, will be worthwhile in the future.

Another asset of the current study is the use of experience-sampling methodology. We assessed participants' hedonic orientation by repeatedly prompting them in daily life to report on their current affect-regulation motivation rather than asking for subjective evaluations on their typical affect-regulation motivation. With this approach, we obtained a more representative indicator of hedonic orientation because we assessed the hedonic-orientation of participants' affect-regulation motivation as they occurred during their daily lives. Participants reported their momentary affect-regulation motivation for the situation in which the experience-sample occurred. We did not, however, ask participants to specifically report their affect-regulation motivation with regard to their event-related affect. Doing so in future studies as well as assessing participants' fluctuations in momentary cognitive control in daily life would be desirable in order to disentangle the process linking hedonic orientation, cognitive control, and hassle reactivity on a within-person basis.

Experience-sampling methodology was also used to study affect reactivity to daily events. This allowed us to investigate events that were personally relevant to participants, thus enhancing ecological validity. Unlike standardized laboratory events, self-reported events in participants' daily lives differ within and across participants. We accounted for variations across measurement occasions and participants by controlling for event importance. It would be interesting to test whether the results could be replicated when standardized laboratory hassles and uplifts were used.

Occurrences of hassles and uplifts were reported retrospectively approximately every two-hours. We preferred a time-based, as opposed to an event-based, study design, as we anticipated an underreporting of events when participants' had to take an active and self-initiating role in event reporting. Study designs that monitor individuals' psychophysiological arousal and prompt individuals to complete the assessment instrument whenever indices of stress appear would be ideal to study affect reactivity. These study designs have been tested, but are not yet reliable in detecting arousal caused by pleasant or unpleasant events (e.g., Fahrenberg & Myrtek, 2001).

In the current study, we focused on inter-individual differences from late childhood to early adulthood. We chose this focus because in adolescence, very little is known regarding the role of cognitive control in affect reactivity and because affect-regulation motivation in adolescence is different from that in adulthood (Riediger et al., 2009). From a developmental perspective, it would be interesting to extend our current investigation to younger children and middle-aged adults. Such investigations can help to understand whether overall higher negative affect reactivity in adolescence as compared to late childhood and adulthood is mediated by individuals' affect-regulation motivation and cognitive control. In addition, the investigation of affect-regulation motivation might clarify the complex empirical evidence on the use and effectiveness of affect-regulation strategies across childhood and adolescence (for reviews see Riediger & Klipker, 2014; Zimmermann & Iwanski, 2014).

Despite sample heterogeneity in some aspects (as for example previously discussed variation in individuals' age, pubertal status, and their parents' socioeconomic background) increase in sample homogeneity and thus statistical power was achieved by conducting the study solely with boys born and raised in Germany. This comes with the important limitation that our study results cannot be generalized to girls or to adolescents from other cultures. The investigation of potential gender or cultural differences constitutes an important task for future studies.

Conclusion

The current study shows that hedonic orientation moderates the association of cognitive control and hassle reactivity in adolescent boys. Thus, unlike suggested by the empirical literature on adult samples, cognitive control is not generally involved in promoting well-being in adolescence. Rather, our results suggest that cognitive control can be involved in empowering adolescents to maintain their emotional well-being when daily hassles challenge a strong hedonic orientation. We conclude that considering individual differences in hedonic orientation and cognitive control might contribute to better understand adolescents' reactions to daily hassles.

Acknowledgements

The authors are grateful to Dulce Erdt, Manuela Meermann and all student assistants of the Max Planck Research Group ‚Affect Across the Lifespan‘ for their help in recruiting participants and conducting the study.

References

Aldwin, C. M., Yancura, L. A., & Boeninger, D. K. (2010). Coping across the lifespan. In R. E. Lerner, A. M. Freund & M. E. Lamb (Eds.), *Handbook of Lifespan Development* (Vol. 2, pp. 298–340). New York: Wiley.

Baddeley, A. D. (2013). Working memory and emotion: ruminations on a theory of depression. *Review of General Psychology, 17*, 20-27. doi: 10.1037/a0030029

Bauer, D. J., & Curran, P. J. (2005). Probing interactions in fixed and multilevel regression: Inferential and graphical techniques. *Multivariate Behavioral Research, 40*, 373-400. doi: 10.1207/s15327906mbr4003_5

Baumeister, R. F., & Heatherton, T. F. (1996). Self-regulation failure: an overview. *Psychological Inquiry, 7*, 1-15. doi: 10.1207/s15327965pli0701_1

Best, J. R., & Miller, P. H. (2010). A developmental perspective on executive function. *Child Development, 81*, 1641-1660. doi: 10.1111/j.1467-8624.2010.01499.x

Bliese, P. (2013). Multilevel: Multilevel functions. R package version 2.5. http://CRAN.R-project.org/package=multilevel.

Byrne, D. G., Davenport, S. C., & Mazanov, J. (2007). Profiles of adolescent stress: The development of the adolescent stress questionnaire (ASQ). *Journal of Adolescence, 30*, 393-416. doi: 10.1016/j.adolescence.2006.04.004

Cohen, J. D., Perlstein, W. M., Braver, T. S., Nystrom, L. E., Noll, D. C., Jonides, J., & Smith, E. E. (1997). Temporal dynamics of brain activation during a working memory task. *Nature, 386*, 604-608. doi: 10.1038/386604a0

Compton, R. J. (2000). Ability to disengage attention predicts negative affect. *Cognition and Emotion, 14*, 401-415.

Compton, R. J., Robinson, M. D., Ode, S., Quandt, L. C., Fineman, S. L., & Carp, J. (2008). Error-monitoring ability predicts daily stress regulation. *Psychological Science, 19*, 702-708. doi: 10.1111/j.1467-9280.2008.02145.x

Corsi, P. M. (1972). *Human memory and the medial temporal region of the brain*. Unpublished doctoral dissertation. McGill University. Montreal, Canada.

Crone, E. A., & Dahl, R. E. (2012). Understanding adolescence as a period of social-affective engagement and goal flexibility. *Nature Reviews Neuroscience, 13*, 636-650. doi: 10.1038/nrn3313

Daneman, M., & Carpenter, P. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior, 19*, 450-466. doi: 10.1016/S0022-5371(80)90312-6

Diener, E. (2000). Subjective well-being: the science of happiness and a proposal for a national index. *American Psychologist*, 55, 34-43. doi: 10.1037/0003-066X.55.1.34

Eccles, J. S., Templeton, J., Barber, B., & Stone, M. (2003). Adolescence and emerging adulthood: The critical passage ways to adulthood. In M. H. Bornstein, L. Davidson, C. L. M. Keyess & K. A. Moore (Eds.), *Well-being. Positive development across the life course* (pp. 383-406). New Jersey: Lawrence Erlbaum Associates.

Egloff, B., Schmukle, S. C., Burns, L. R., & Schwerdtfeger, A. (2006). Spontaneous emotion regulation during evaluated speech tasks: associations with negative affect, anxiety expression, memory, and physiological responding. *Emotion, 6*, 356–366. doi: 10.1037/1528-3542.6.3.356

Engle, R. W. (2010). Role of working-memory capacity in cognitive control. *Current Anthropology, 51*, S1-S10.

Engle, R. W., Kane, M. J., & Tuholski, S. W. (1999). Individual differences in working memory capacity and what they tell us about controlled attention, general fluid intelligence and functions of the prefrontal cortex. In A. Miyake & P. Shah (Eds.), *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 102-134). New York: Cambridge University Press.

Fahrenberg, J., & Myrtek, M. (2001). *Progress in ambulatory assessment: Computer-assisted psychological and psychophysiological methods in monitoring and field studies*. Ashland, OH: Hogrefe & Huber Publishers.

Ge, X., Lorenz, F. O., Conger, R. D., Elder, G. H., & Simons, R. L. (1994). Trajectories of stressful life events and depressive symptoms during adolescence. *Developmental Psychology, 30*, 467-483. doi: 10.1037/0012-1649.30.4.467

Gray, J. R., & Braver, T. S. (2007). Integration of emotion and cognitive control: A neurocomputational hypothesis of dynamic goal regulation. In S. C. Moore & M. Oaksford (Eds.), *Emotional Cognition: From brain to behavior* (Vol. 44, pp. 289-316). Amsterdam: John Benjamins Publishing Company.

Gross, J. J. (2014). Emotion regulation: Conceptual and empirical foundations. In J. J. Gross (Ed.), *Handbook of Emotion Regulation* (pp. 3-20). New York: Guilford Press.

Gross, J. J., & Thompson, R. (2007). Emotion regulation: Conceptual foundations. In J. J. Gross (Ed.), *Handbook of Emotion Regulation* (pp. 3-24). New York: Guilford Press.

Gullone, E., & Taffe, J. (2012). The emotion regulation questionnaire for children and adolescents (ERQ-CA): A psychometric evaluation. *Psychological Assessment, 24*, 409-417. doi: 10.1037/a0025777

Gyurark, A., Gross, J. J., & Etkin, A. (2011). Explicit and implicit emotion regulation: A dual-process framework. *Cognition and Emotion, 25*, 400-412. doi: 10.1080/02699931.2010.544160

Heimpel, S. A., Wood, J. V., Marshall, M. A., & Brown, J. D. (2002). Do people with low self-esteem really want to feel better? Self-esteem differences in motivation to repair negative moods. *Journal of Personality and Social Psychology, 82*, 128-147. doi: 10.1037/0022-3514.82.1.128

Hoeksma, J. B., Oosterlaan, J., & Schipper, E. M. (2004). Emotion regulation and the dynamics of feelings: A conceptual and methodological framework. *Child Development, 75*, 354-360. doi: 10.1111/j.1467-8624.2004.00677.x

Inzlicht, M., Bartholow, B. D., & Hirsh, J. B. (2015). Emotional foundations of cognitive control. *Trends in Cognitive Sciences, 19*, 126-132. doi: 10.1016/j.tics.2015.01.004

Johnson, D. R. (2009). Emotional attention set-shifting and its relationship to anxiety and emotion regulation. *Emotion, 9*, 681-690. doi: 10.1037/a0017095

Kahneman, D., & Richard, H. T. (2006). Utility maximization and experienced utility. *Journal of economic perspectives, 20*, 221-234. doi: 10.1257/089533006776526076

Koolhaas, J. M., Bartolomcci, A., Buwalda, B. K., de Boer, S. F., Flügge, G., Korte, S. M., . . . Fuchs, E. (2011). Stress revisited: A critical evaluation of the stress concept. *Neuroscience and Biobehavioral Reviews, 35*, 1291-1301.

Kuppens, P., & Verduyn, P. (2015). Looking at emotion regulation through the window of emotion dynamics. *Psychological Inquiry, 26*, 72-79. doi: 10.1080/1047840X.2015.960505

Larsen, R. J. (2000). Toward a science of mood regulation. *Psychological Inquiry, 11*, 129-141. doi: 10.1207/S15327965PLI1103_01

Larson, R., Moneta, G., Richards, M. H., & Wilson, S. (2002). Continuity, stability, and change in daily emotional experience across adolescence. *Child Development, 73*, 1151-1165. doi:10.1111/1467-8624.00464

Luna, B. (2009). Developmental changes in cognitive control through adolescence. Advances in *Child Development and Behavior, 37*, 233-278. doi: 10.1016/S0065-2407(09)03706-9

Maier, S. F., & Watkins, L. R. (2005). Stressor controllability and learned helplessness: The roles of the dorsal raphe nucleus, serotonin, and corticotropin-releasing factor. *Neuroscience and Biobehavioral Reviews, 29*, 829-841. doi: 10.1016/j.neubiorev.2005.03.021

Mauss, I. B., Bunge, S. A., & Gross, J. J. (2007). Automatic emotion regulation. *Social and Personality Psychology Compass, 1*, 146-167. doi: 10.1111/j.1751-9004.2007.00005.x

Mauss, I. B., & Tamir, M. (2014). Emotion goals: how their content, structure, and operation shape emotion regulation. In J. J. Gross (Ed.), *Handbook of Emotion Regulation* (pp. 361-375). New York: The Guilford Press.

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience, 24*, 167-202. doi: 10.1146/annurev.neuro.24.1.167

Olson, E. A., & Luciana, M. (2008). The development of prefrontal cortex functions in adolescence: Theoretical models and a possible dissociation of dorsal versus ventral subregions. In C. A. Nelson & M. Luciana (Eds.), *Handbook of developmental cognitive neuroscience* (Vol. 2, pp. 575-590). Cambridge: MIT Press.

Parrott, W. G. (1993). Beyond hedonism: Motives for inhibiting good moods and for maintaining bad moods. In D. M. Wegner & J. W. Pennebaker (Eds.), *Handbook of Mental Control* (pp. 278-305). Englewood Cliffs, NJ: Prentice Hall.

Pe, M. L., Raes, F., Koval, P., Brans, K., Verduyn, P., & Kuppens, P. (2013). Interference resolution moderates the impact of rumination and reappraisal on affective experiences in daily life. *Cognition and Emotion, 27*, 492–501. doi: 10.1080/02699931.2012.719489

Pe, M. L., Raes, F., & Kuppens, P. (2015). The cognitive building blocks of emotion regulation: Ability to update working memory moderates the efficacy of rumination and reappraisal on emotion. *PLoS ONE, 8*(7), 1-12. doi: 10.1371/journal.pone.0069071

Prencipe, A., Kesek, A., Cohen, J., Lamm, C., Lewis, M. D., & Zelazo, P. D. (2010). Development of hot and cool executive function during the transition to adolescence. *Journal of Experimental Child Psychology*, *108*, 621-637. doi: 10.1016/j.jecp.2010.09.008

Quevedo, K. M., Benning, S. D., Gunnar, M. R., & Dahl, R. E. (2009). The onset of puberty: Effects on the psychophysiology of defensive and appetitive motivation. *Development and Psychopathology, 21*, 27-45. doi: 10.1017/S0954579409000030

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models. Applications and data analysis methods*. Newbury Park, CA: Sage Publications.

Rickenbach, E. H., Condeelis, K. L., & Haley, W. E. (2015). Daily stressors and emotional reactivity in individuals with mild cognitive impairment and cognitively healthy controls. *Psychology and Aging*, *30*, 420-431. doi: 10.1037/a0038973

Riediger, M. (2015). Affect-regulation motivation. In J. D. Wright (Ed.), *International Encyclopedia of the Social and Behavioral Sciences* (Vol. 1, pp. 241-247). Oxford: Elsevier.

Riediger, M., & Klipker, K. (2014). Emotion regulation in adolescence. In J. J. Gross (Ed.), *Handbook of emotion regulation* (2 ed., pp. 187-202). New York: Guilford Press.

Riediger, M., Schmiedek, F., Wagner, G. G., & Lindenberger, U. (2009). Seeking pleasure and seeking pain: Differences in prohedonic and contra-hedonic motivation from adolescence to old age. *Psychological Science, 20*, 1529-1535. doi: 10.1111/j.1467-9280.2009.02473.x

Riediger, M., Wrzus, C., & Wagner, G. G. (2014). Happiness is pleasant, or is it? Implicit representations of affect valence are associated with contra-hedonic motivation and mixed affect in daily life. *Emotion, 14*, 950-961. doi: 10.1037/a0037711

Robinson, M. D. (2007). Gassing, braking, and self-regulating: Error self-regulation, well-being, and goal-related processes. *Journal of Experimental Social Psychology, 43*, 1-16. doi: 10.1016/j.jesp.2005.11.009

Salthouse, T. A., Babock, R. L., & Shaw, R. J. (1991). Effects of adult age on structural and operational capacities in working memory. *Psychology and Aging, 6*, 118-127. doi: 10.1037/0882-7974.6.1.118

Schleepen, T. M. J., & Jonkman, L. M. (2010). The development of non-spatial working memory capacity during childhood and adolescence and the role of interference control: An N-back task study. *Developmental Neuropsychology, 35*, 37-56. doi: 10.1080/87565640903325733

Schmeichel, B. J., & Demaree, H. A. (2010). Working memory capacity and spontaneous emotion regulation: High capacity predicts self-enhancement in response to negative feedback. *Emotion, 10*, 739-744. doi: 10.1037/a0019355

Schmeichel, B. J., Volokhov, R. N., & Demaree, H. A. (2008). Working memory capacity and the self-regulation of emotional expression and experience. *Journal of Personality and Social Psychology, 95*, 1526-1540. doi: 10.1037/a0013345

Schweizer, S., Grahn, J., Hampshire, A., Mobbs, D., & Dalgleish, T. (2013). Training the emotional brain: improving affective control through emotional working memory training. *Journal of Neuroscience, 33*, 5301–5311. doi: 10.1523/JNEUROSCI.2593-12.2013

Silk, J. S., Siegle, G. J., Whalen, D. J., Ostapenko, L. J., Ladouceur, C. D., & Dahl, R. E. (2009). Pubertal changes in emotional information processing: Pupillary, behavioral, and subjective evidence during emotional word identification. *Development and Psychopathology, 21*, 7-26. doi: 10.1017/S0954579409000029

Silk, J. S., Steinberg, L., & Morris, A. S. (2003). Adolescents' emotion regulation in daily life: links to depressive symptoms and problem behavior. *Child Development, 74*, 1869-1880. doi: 10.1046/j.1467-8624.2003.00643.x

Singer, J. D., & Willett, J. B. (2003). *Applied longitudinal data analysis*. New York: Oxford University Press.

Sprague, J., Verona, E., Kalkhoff, W., & Kilmer, A. (2011). Moderators and mediators of the stress-aggression relationship: Executive function and state anger. *Emotion, 11*, 61-73. doi: 10.1037/a0021788

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

Tamir, M., & Ford, B. Q. (2012). Should people pursue feelings that feel good or feelings that do good? Emotional preferences and well-being. *Emotion, 12*, 1061-1070. doi: 10.1037/a0027223

Tamir, M., Mitchell, C., & Gross, J. J. (2008). Hedonic and instrumental motives in anger regulation: Research report. *Psychological Science, 19*, 324-328. doi: 10.1111/j.1467-9280.2008.02088.x

Tsai, J. L., Knutson, B., & Fung, H. H. (2006). Cultural variation in affect valuation. *Journal of Personality and Social Psychology, 90*, 288-307. doi: 10.1037/0022-3514.90.2.288

Van Honk, J., Tuiten, A., Verbaten, R., Van Den Hout, M., Koppeschaar, H., Thijssen, J., & De Haan, E. (1999). Correlations among salivary testosterone, mood, and selective attention to threat in humans. *Hormones and Behavior, 36*, 17-24. doi: 10.1006/hbeh.1999.1521

Volokhov, R. N., & Demaree, H. A. (2010). Spontaneous emotion regulation to positive and negative stimuli. *Brain and Cognition, 73*, 1-6. doi: 10.1016/j.bandc.2009.10.015

Wood, J. V., Heimpel, S. A., Manwell, L. A., & Whittington, E. J. (2009). This mood is familiar and I don't deserve to feel better anyway: Mechanisms underlying self-esteem differences in motivation to repair sad moods. *Journal of Personality and Social Psychology, 96*, 363-380. doi: 10.1037/a0012881

Zimmermann, P., & Iwanski, A. (2014). Emotion regulation from early adolescence to emerging adulthood and middle adulthood: Age differences, gender differences, and emotion-specific developmental variations. *International Journal of Behavioral Development, 38*, 182-194. doi: 10.1177/0165025413515405

Table 1

Descriptive Statistics and Zero-Order Correlation Coefficients for Central Model Variables

	M (*SD*)	*MIN – MAX*	HR	UR	HO	CC
Hassle Reactivity (HR)[a]	1.49 (1.04)	-2.19 – 5.47	-	-	-	-
Uplift Reactivity (UR)[a]	0.46 (1.03)	-4.53 – 4.06	.280*	-	-	-
Hedonic Orientation (HO)	0.57 (0.24)	0.01 – 0.98	.063	.156	-	-
Cognitive Control (CC)	0.0 (0.71)	-2.08 – 1.38	.164*	.293*	.004	-
Age	15.36 (2.66)	10.88 – 20.81	-.098	.134	-.050	.347*

*$p < .05$.

[a] Aggregated mean scores per person were used to calculate correlations with the within-person variables hassle reactivity (i.e., negative affect towards daily hassles) and uplift reactivity (i.e., positive affect towards daily uplifts).

Table 2

Effect of Cognitive Control and Hedonic Orientation on Affect Reactivity Towards Daily Hassles (Hassle Reactivity): Results From Multilevel Regression Models

Model parameter	Model 1 *B* (*SE*)	Model 2 *B* (*SE*)
Fixed effects		
Intercept	1.485 (0.059)*	1.476 (0.057)*
Cognitive control	0.156 (0.084)	0.212 (0.085)*
Hedonic orientation	0.220 (0.250)	0.093 (0.238)
Cognitive control × Hedonic orientation	-1.077 (0.378)*	-0.898 (0.359)*
Age (in years)	—	-0.038 (0.023)
Reappraisal	—	0.102 (0.083)
Suppression	—	-0.030 (0.071)
Event importance	—	0.222 (0.016)*
Time lag	—	0.053 (0.018)*
Pseudo-R^2 statistics		
Modeled between-person variance[a]	7.52%	7.95%
Modeled within-person variance[b]	0.00%	15.62%

Note. Restricted maximum likelihood parameter estimates were obtained using multilevel regression models with two levels. All variables were centered to the sample's mean prior inclusion in the models. Level 1 comprised measurement occasions of hassles. For Model 1 the level 1 equation is defined by: $Affect_{ij} = \beta_{0j} + r_{ij}$ (where $\beta_{0j} =$ random intercept, and $r_{ij} =$ random residual associated with the *i*th assessment in the *j*th individual). Level 2 comprised persons: $\beta_{0j} = \gamma_{00} + \gamma_{01}CC + \gamma_{02}HO + \gamma_{03}CC \times HO + \mu_{0j}$ (where CC = cognitive control, HO = hedonic orientation, $\gamma_{00} =$ fixed intercept, $\gamma_{0k} =$ fixed slope for the *k*th predictor, and $\mu_{0j} =$ residual for the *j*th person).

For Model 2 the level 1 equation is defined by: $Affect_{ij} = \beta_{0j} + \beta_{1j}IMP + \beta_{2j}TIME + r_{ij}$

$\beta_{0j} =$ random intercept, β_{kj}

$r_{ij} =$

$\beta_{0j} = \gamma_{00} + \gamma_{01}CC + \gamma_{02}HO + \gamma_{03}CC \times HO + \gamma_{04}AGE + \gamma_{05}REA + \gamma_{06}SUP + \mu_{0j}$ (where CC = cognitive control, HO = hedonic orientation, AGE = participant's age, REA = reappraisal, SUP = suppression, $\gamma_{00} =$ fixed intercept, $\gamma_{0k} =$ fixed slope for the kth predictor, and $\mu_{0j} =$ residual for the intercept of the jth person). The random slopes are defined by: $\beta_{kj} = \gamma_{k0} + \mu_{kj}$ (where γ_{k0} = fixed intercept of the kth slope of the jth person, μ_{kj} = residual for the kth slope of the jth person).

[a] The modeled between-person variance represents proportional reductions in the level-2 residual variance of μ_{0j} in comparison with models without explanatory variables (Singer & Willett, 2003).

[b] The modeled within-person variance represents proportional reductions in the level-1 residual variance of r_{ij} in comparison with models without explanatory variables (Singer & Willett, 2003).

*p < .05.

Table 3

Effect of Cognitive Control and Hedonic Orientation on Affect Reactivity Towards Daily Uplifts (Uplift Reactivity): Results From Multilevel Regression Models

Model parameter	Model 1 *B* (*SE*)	Model 2 *B* (*SE*)
Fixed effects		
Intercept	0.443 (0.041)*	0.437 (0.041)*
Cognitive control	0.229 (0.058)*	0.218 (0.061)*
Hedonic orientation	0.404 (0.172)*	0.294 (0.170)
Cognitive control × Hedonic orientation	-0.378 (0.259)	-0.216 (0.256)
Age (in years)	—	-0.013 (0.017)
Reappraisal	—	0.024 (0.060)
Suppression	—	-0.022 (0.051)
Event importance	—	0.188 (0.017)*
Time lag	—	0.034 (0.016)*
Pseudo-R^2 statistics		
Modeled between-person variance[a]	16.99%	16.20%
Modeled within-person variance[b]	0.00%	16.91%

Note. Restricted maximum likelihood parameter estimates were obtained using multilevel regression models with two levels. All variables were centered to the sample's mean prior inclusion in the models. Level 1 comprised measurement occasions of uplifts. For Model 1 the level 1 equation is defined by: $Affect_{ij} = \beta_{0j} + r_{ij}$ (where $\beta_{0j} =$ random intercept, and $r_{ij} =$ random residual associated with the *i*th assessment in the *j*th individual). Level 2 comprised persons: $\beta_{0j} = \gamma_{00} + \gamma_{01}CC + \gamma_{02}HO + \gamma_{03}CC \times HO + \mu_{0j}$ (where CC = cognitive control, HO = hedonic orientation, $\gamma_{00} =$ fixed intercept, $\gamma_{0k} =$ fixed slope for the *k*th predictor, and $\mu_{0j} =$ residual for the *j*th person).

For Model 2 the level 1 equation is defined by: $Affect_{ij} = \beta_{0j} + \beta_{1j}IMP + \beta_{2j}TIME + r_{ij}$

$\beta_{0j} =$ random intercept, β_{kj}

$r_{ij} =$

$\beta_{0j} = \gamma_{00} + \gamma_{01}CC + \gamma_{02}HO + \gamma_{03}CC \times HO + \gamma_{04}AGE + \gamma_{05}REA + \gamma_{06}SUP + \mu_{0j}$ (where CC = cognitive control, HO = hedonic orientation, AGE = participant's age, REA = reappraisal, SUP = suppression, $\gamma_{00} =$ fixed intercept, $\gamma_{0k} =$ fixed slope for the kth predictor, and $\mu_{0j} =$ residual for the intercept of the jth person). The random slopes are defined by: $\beta_{kj} = \gamma_{k0} + \mu_{kj}$ (where γ_{k0} = fixed intercept of the kth slope of the jth person, μ_{kj} = residual for the kth slope of the jth person).

[a] The modeled between-person variance represents proportional reductions in the level-2 residual variance of μ_{0j} in comparison with models without explanatory variables (Singer & Willett, 2003).

[b] The modeled within-person variance represents proportional reductions in the level-1 residual variance of r_{ij} in comparison with models without explanatory variables (Singer & Willett, 2003).

*$p < .05$.

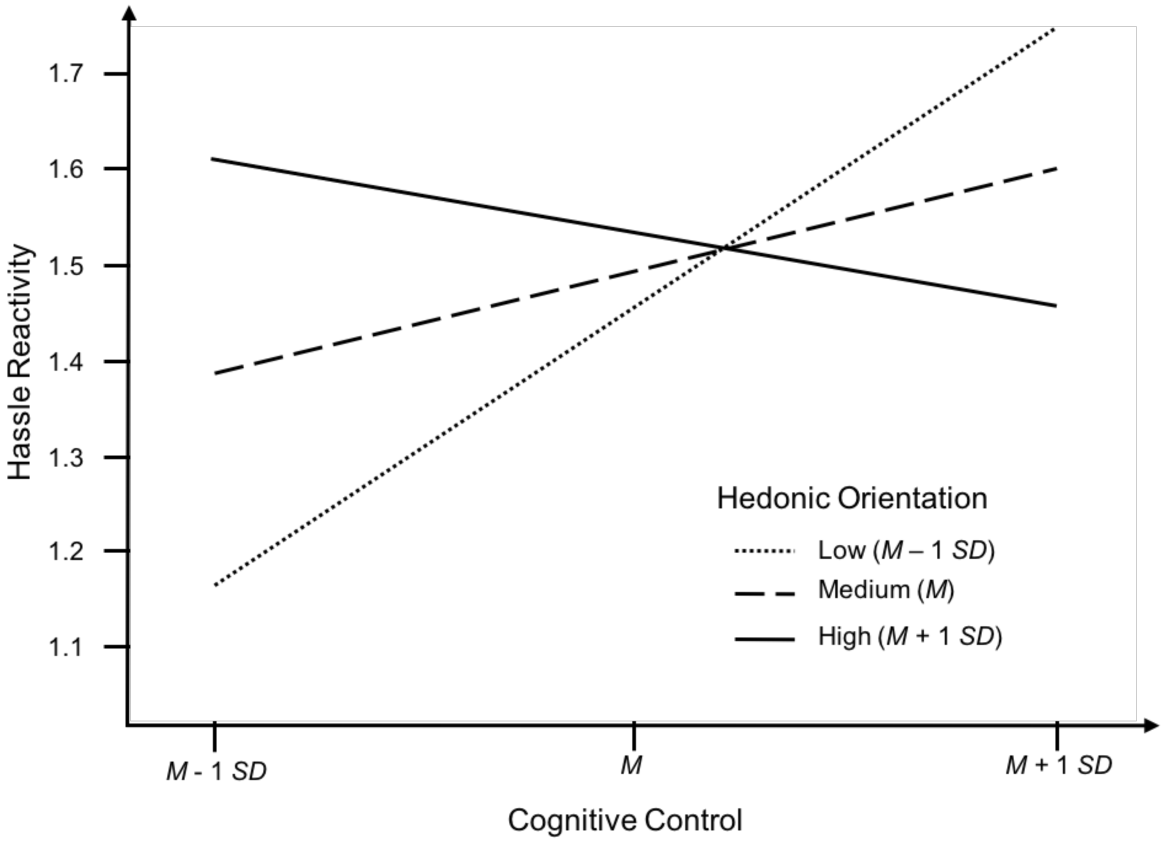

Figure 1. Model-predicted associations between cognitive control and hassle reactivity (i.e., negative affect towards daily hassles) for adolescents with low, medium, and high levels of hedonic orientation. *M* = mean, *SD* = standard deviation.

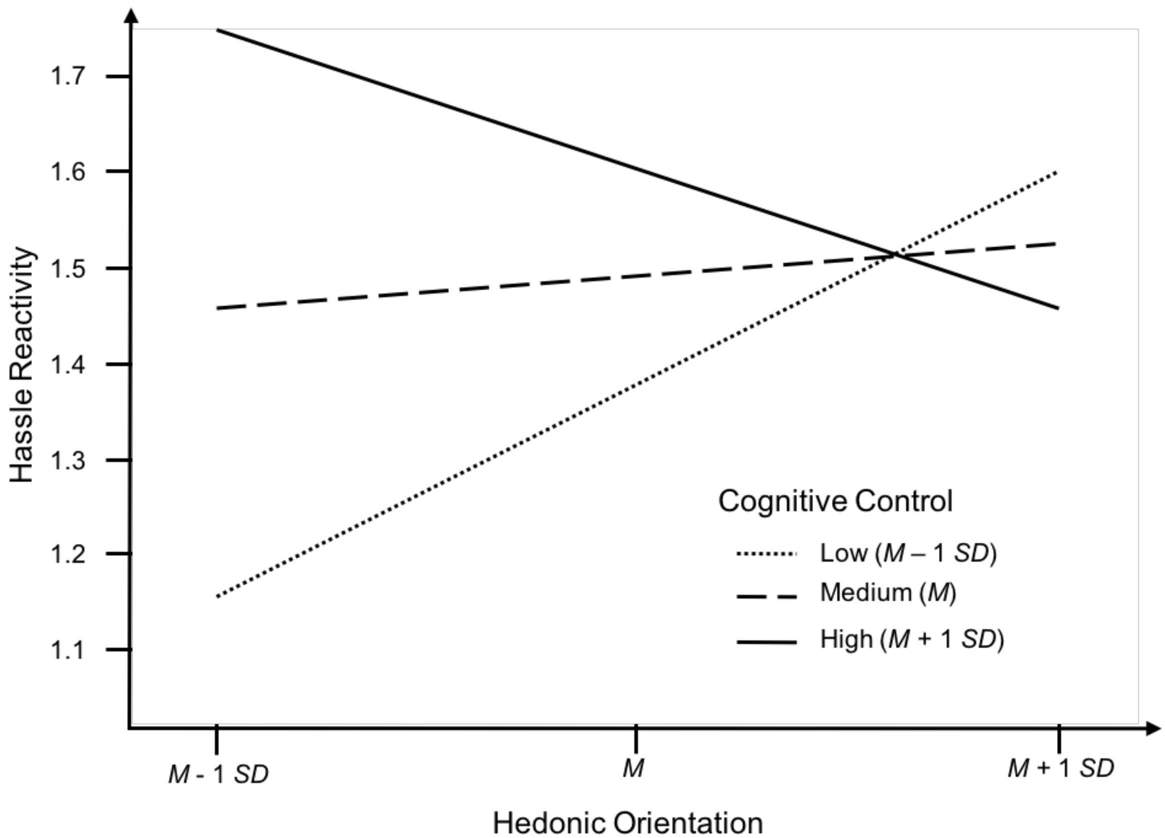

Figure 2. Model-predicted associations between hedonic orientation and hassle reactivity (i.e., negative affect towards daily hassles) for adolescents with low, medium, and high cognitive control. *M* = mean, *SD* = standard deviation.

Supplementary material to

"Hedonic Orientation Moderates the Association Between Cognitive Control and Affect Reactivity to Daily Hassles in Adolescent Boys" ***Klipker, Wrzus, Rauers, & Riediger***

The main findings of the manuscript were that for adolescents with low hedonic orientation, higher cognitive control was associated with stronger affect reactivity towards daily hassles. Additionally, higher hedonic orientation was associated with lower hassle reactivity, but only for adolescents with high cognitive control. This effect was irrespective of participants' age. The supplementary material covers whether results were influenced by participants' pubertal development.

Puberty-related physical development was assessed using the self-report Pubertal Development Scale (PDS, Petersen, Crockett, Richards, & Boxer, 1988). The PDS for boys includes questions regarding growth of pubic hair, development of genitals, and changes in voice. Based on the summed answers on these questions, boys were classified into five distinct stages of pubertal development. Of 149 participants, 13% had not entered puberty, 16% were in the early stage, 25% in the middle stage, 22% in the late stage of puberty, and 24% had completed pubertal development.

The zero-order correlations between pubertal development and all central variables of the manuscript (i.e., hedonic orientation, cognitive control, negative affect reactivity, positive affect reactivity, age) are provided in Table S1.

For the main analyses presented in Table 2 of the manuscript, where hedonic orientation and cognitive control were used to predict hassle reactivity, we provide Table S2 (Model 1) with results from the control analysis including pubertal development as a covariate. For the main analyses presented in Table 3 of the manuscript, where hedonic orientation and cognitive control were used to predict affect reactivity towards daily uplifts, we provide Table S2 (Model 2) with results from the control analysis including pubertal development as a covariate. The results show that pubertal development did not alter the model results. We summarize these control analyses in the main manuscript.

Zero-order correlations of all central variables with pubertal development:

Supplementary Table S1

Zero-Order Correlation Coefficients Between Pubertal Development and all Central Model Variables

	Hassle reactivity[a]	Uplift reactivity[a]	Hedonic orientation	Cognitive control	Age
Puberty	-.043	.161	-.013	.390*	.821*

*$p < .05$.

[a] Aggregated mean scores per person were used to calculate correlations with the within-person variables hassle reactivity (i.e., negative affect towards daily hassles) and uplift reactivity (i.e., positive affect towards daily uplifts).

Model 2 of Tables 2 and 3 in manuscript including pubertal development as covariate:

Supplementary Table S2

Effect of Cognitive Control and Hedonic Orientation on Affect Reactivity Towards Daily Hassles (Hassle Reactivity) and Uplifts (Uplift Reactivity): Results From Multilevel Regression Models

	Model 1	*Model 2*
	Hassle Reactivity	Uplift Reactivity
Model parameter	*B* (*SE*)	*B* (*SE*)
Fixed effects		
Intercept	1.478 (0.057)*	0.437 (0.041)*
Cognitive control	0.200 (0.087)*	0.217 (0.062)*
Hedonic orientation	0.119 (0.239)	0.302 (0.170)
Cognitive control × Hedonic orientation	-0.970 (0.358)*	-0.240 (0.255)
Puberty	-0.050 (0.047)	-0.020 (0.033)
Reappraisal	0.090 (0.083)	0.021 (0.060)
Suppression	-0.037 (0.072)	-0.024 (0.051)
Event importance	0.222 (0.016)*	0.188 (0.017)*
Time lag	0.053 (0.018)*	0.034 (0.016)*
Pseudo-R^2 statistics		
Modeled between-person variance[a]	7.23%	16.47%
Modeled within-person variance[b]	15.62%	16.91%

Note. Restricted maximum likelihood parameter estimates were obtained using multilevel regression models with two levels. All variables were centered to the sample's mean prior inclusion in the models. Level 1 comprised measurement occasions of hassles and uplifts. For Model 1 the level 1 equation is defined by: $Affect_{ij} = \beta_{0j} + r_{ij}$ (where β_{0j} = random intercept, and r_{ij} = random residual associated with the *i*th assessment in the *j*th individual). Level 2 comprised persons: $\beta_{0j} = \gamma_{00} + \gamma_{01}CC + \gamma_{02}HO + \gamma_{03}CC \times HO + \mu_{0j}$ (where CC = cognitive control, HO = hedonic orientation, γ_{00} = fixed intercept, γ_{0k} = fixed slope for the *k*th predictor, and μ_{0j} = residual for the *j*th person).

For Model 2 the level 1 equation is defined by: $Affect_{ij} = \beta_{0j} + \beta_{1j}IMP + \beta_{2j}TIME + r_{ij}$

β_{0j} = random intercept, β_{kj} = random slope for the kth

$r_{ij} =$ random residual associated with the ith assessment in the jth individual). Three level 2 equations comprised persons. The random intercept is defined by: $\beta_{0j} = \gamma_{00} + \gamma_{01}CC + \gamma_{02}HO + \gamma_{03}CC \times HO + \gamma_{04}PUB + \gamma_{05}REA + \gamma_{06}SUP + \mu_{0j}$ (where CC = cognitive control, HO = hedonic orientation, PUB = participant's status of pubertal development, REA = reappraisal, SUP = suppression, $\gamma_{00} =$ fixed intercept, $\gamma_{0k} =$ fixed slope for the kth predictor, and $\mu_{0j} =$ residual for the intercept of the jth person). The random slopes are defined by: $\beta_{kj} = \gamma_{k0} + \mu_{kj}$ (where γ_{k0} = fixed intercept of kth slope of the jth person, $\mu_{kj} =$ residual for the kth slope of the jth person).

[a] The modeled between-person variance represents proportional reductions in the level-2 residual variance of μ_{0j} in comparison with models without explanatory variables (Singer & Willett, 2003).

[b] The modeled within-person variance represents proportional reductions in the level-1 residual variance of r_{ij} in comparison with models without explanatory variables (Singer & Willett, 2003).

$^*p < .05$.

Supplementary References

Petersen, A. C., Crockett, L., Richards, M., & Boxer, A. (1988). A self-report measure of pubertal status: Reliability, validity, and initial norms. *Journal of Youth and Adolescence, 17*, 117-133. doi: 10.1007/BF01537962