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The boiling blood predisposition: The role of stimulation processing capabilities in anger regulation

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ABSTRACT

People regulate their anger using various strategies applied to different phases of the emotional process. However, research investigating the effectiveness of anger regulation strategies in reducing anger is inconsistent, and some evidence indicates individual differences as a factor behind this variability. We aimed to test the role of temperament (stimulation processing capabilities, SPC) in two phases of anger regulation: vulnerability to anger arousal and reducing experienced anger. The study was conducted using a questionnaire and an experimental procedure. Participants (N = 241) completed the Formal Characteristics of Behavior – Temperament Inventory (Revised version). During the experiment, they performed two tasks: an unsolvable task that induced anger, and a task that activated an anger regulation strategy (humor, downplaying, rumination, or distraction). The state of anger was measured three times with a self-report: before the experiment started, after anger induction, and after applying the anger regulation strategy. We used linear mixed-effects models to analyze the data.

The results showed that people with greater SPC are less prone to experiencing anger and decrease their anger more effectively. However, various components of SPC (emotional reactivity and endurance) have different significance in each phase and for particular strategies.

1. Introduction

People try to manage their anger in many ways. They can do it consciously (e.g., when they avoid places that irritate them) or unconsciously (e.g., when they suppress anger by taking the blame for a frustrating situation). In addition, the actions one takes may calm one down (e.g., when steadily explaining the misunderstanding behind a situation), or maintain or even exacerbate the level of one's emotions (e.g., when we constantly reflect on). All of these efforts are part of an individual's way of regulating emotions.

According to *the process model of emotion regulation* (Gross, 2014), emotion regulation is defined as the external and internal processes responsible for monitoring, evaluating, and modifying emotional reactions, especially regarding their intensity and temporal characteristics. These modifications may be employed before or after an emotion arises. The effect of emotion regulation may intensify, maintain, or reduce the current level of emotions. These changes might be observable in behavior, physiological changes, and the subjective experience of emotions.

An individual may employ various cognitive and behavioral techniques in order to modify or maintain their current emotional state. These activities are known as emotion regulation strategies (Webb et al., 2012). In the context of regulating anger, many strategies can be distinguished (see, e.g. Páez et al., 2013). For example, imagine your sibling borrowing your bike again without asking, even though they know well that you do not like it. Firstly, we may focus on the incident, think about it constantly, and thus apply a *rumination* strategy (Ray et al., 2008). Secondly, we may start to think about things unrelated to the angry feelings and/or take up activities that engage our attention. In this case, shifting our attention to other stimuli means using a *distraction* strategy (Gerin et al., 2006). Thirdly, we might think we rarely use this bike anyway. In this way, we minimize the importance of the situation that caused the anger by applying a *downplaying* strategy (Geisler et al., 2009). Finally, we can look at the funny side of the situation, for example by recalling our sibling clumsily trying to explain their behavior every time they do it. Changing perspective in such a way as to make the angering problem seem funny is using a *humor* strategy (Geisler et al., 2009).

Emotion regulation strategies may differ in their effectiveness. Any research evaluating the effectiveness of anger regulation must identify

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precisely what the research goals (criteria of 'effectiveness') take into account. Like many researchers (e.g., Ray et al., 2008), in our study we focus on decreasing anger arousal. According to this criterion, all regulatory strategies might be divided into functional and dysfunctional strategies that do or do not support the decrease of anger arousal, respectively (Kubiak et al., 2011). Thus, the use of functional strategies is recognized as effective anger regulation. However, previous research on the effectiveness of emotion regulation is diverse and displays a lack of consensus regarding the functionality of specific strategies (Webb et al., 2012). Apart from humor, which is so far approved as a functional strategy (Geisler et al., 2009), there are inconclusive findings concerning most strategies' impact on the anger regulation process. Research shows that some techniques help individuals decrease their level of anger, but other techniques do not (see, e.g., Bushman et al., 2005; Geisler et al., 2009; Germain & Kangas, 2015; Wimalaweera & Moulds, 2008). This prompts us to consider the conditions that make particular strategies dysfunctional. A direction that may shed light on the inconsistency of these results is the context of individual differences. Incorporating individual properties into emotion regulation analyses may change general beliefs about the effectiveness of particular strategies. For example, Germain and Kangas's (2015) research on anger regulation in people with a high level of trait anger showed that suppression effectively decreases angry feelings. These findings are inconsistent with the results of earlier studies in which suppression was found to be an ineffective anger regulation strategy (Quartana & Burns, 2007). Therefore, evidence regarding different anger regulation strategies in the context of individual properties is needed.

John and Eng (2014) propose a comprehensive hypothetical and theoretical framework for analyzing individual differences in emotion regulation and anger regulation. According to their *model of individual differences in emotion regulation*, the effectiveness of emotion regulation strategies also depends on so-called *individual antecedents*, i.e., personality and temperamental traits. Because some research (Kashdan et al., 2016) on the anger experience does not confirm a direct relation between the Big Five personality traits and anger, we assume that temperament could be a more promising predictor of anger regulation. Numerous studies, including brain (e.g., Aslan & Arkar, 2016) and behavioral research (e. g. Harmon-Jones & Peterson, 2008), have shown links between anger and temperament.

Considering temperamental traits, we based our research on the Regulative Theory of Temperament (RTT; Strelau, 1996, 2012). According to the assumptions of the RTT, temperament is defined as a basic, primarily biologically determined and relatively stable system of personality traits. The RTT identifies seven temperament traits: four in the energetic domain (endurance, emotional reactivity, activity, and sensory sensitivity) and three temporal ones (briskness, perseveration, and rhythmicity). One of the assumptions of the RTT indicates that the primary function of temperament is the regulation of stimulation. Therefore, it was conjectured that temperament could also be expressed as stimulation processing capabilities (SPC), which are primarily determined by two features: endurance and emotional reactivity. Emotional reactivity (ER) is the tendency to react intensely to emotion-generating stimuli; it is expressed in high emotional sensitivity and low emotional endurance. At the same time, endurance (EN) addresses the ability to react adequately in situations related to intense external stimulation or long-lasting or highly stimulative activity. These traits are responsible for accumulating and discharging energy stored in the body and regulating emotions. Any form of self-regulation is related to energy effort, especially in situations in which a person consciously and intentionally tries to influence the emergence, course, and consequences of specific emotions.

People with poor stimulation processing capabilities, i.e., those characterized by low endurance and high emotional reactivity, tend to avoid stimulation and perform best in low-stimulation conditions (e. g., they spend their free time reading books at home). Conversely, people with good stimulation processing capabilities, i.e., those characterized by high endurance and low emotional reactivity, are prone to seeking stimulation and perform best in high-stimulation conditions (e.g., their hobby might be extreme sports).

Research on SPC shows that people with lower SPC can react with negative emotions and aggressive behavior when the level of stimulation exceeds their processing capabilities (Eliasz, 1991). In another study (Gilam et al., 2018) which employed fMRI measurement, researchers stimulated the prefrontal cortex to determine its significance for effective anger regulation. The results revealed that stimulation to areas responsible for the ability to process stimulation made the subjects display lower anger levels after the experiment than those who did not receive prefrontal stimulation. This outcome shows that people with greater SPC reduce experienced anger more effectively; h. However, the participants' type of anger regulation strategy was not controlled in Gilam et al.'s experiment.

Our study aimed to test the role of SPC in two phases of the anger regulation process: vulnerability to anger arousal and the effectiveness of anger regulation strategies.

For the vulnerability phase, we made predictions based on the assumptions of the RTT. According to the RTT, people with low SPC are more sensitive to emotional stimuli, and they can endure less in circumstances that cause emotional arousal. Therefore, we expected that low SPC would be related to a higher propensity for anger evocation because an angry reaction may be the effect of such people's ability to process sensation load being exceeded. At the same time, based on the knowledge that ER is the temperamental trait that indicates the threshold for arousal, we wanted to determine whether this trait contributes more than EN to anger vulnerability. On the other hand, we hypothesized that EN would be more related to efficient anger reduction than ER during the regulation phase.

In the regulation phase, we focused on the general effectiveness of four anger regulation strategies: humor, downplaying, rumination, and distraction. Based on the results of previous studies (Bushman et al., 2005; Geisler et al., 2009; Germain & Kangas, 2015), we hypothesized that humor, distraction, and downplaying reduce anger, but rumination increases it.

According to Gilam et al.'s (2018) findings, higher SPC allows individuals to reduce anger more effectively. Thus, we expect SPC to facilitate the effectiveness of all anger regulation strategies. However, as humor and downplaying are strategies that require a different appraisal of the situation and thus seem to need more cognitive capability, we expect that SPC will be a moderator of the effectiveness of each strategy.

2. Materials and methods

2.1. Sample

241 students participated in the study: 121 women and 120 men (M_{age} = 21.96; *SD* = 2.66). Due to the mathematical nature of the experimental task, the invitation to participate in the study included information that was intended for people who have no difficulties in mathematical calculations at primary school level. All participants gave their voluntary consent to participate in the study and received a cinema voucher as remuneration.

2.2. Measures

The Formal Characteristics of Behaviour – Temperament Inventory (FCB-TI) (Cyniak-Cieciura, Zawadzki, & Strelau, 2016) contains seven scales: briskness (α = 0.73), perseverance (α = 0,75), rhythmicity (α = 0.78), sensory sensitivity (α = 0.79), emotional reactivity (α = 0.88), endurance (α =0.79) and activity (α = 0.83). In total, the FCB-TI includes 100 items (with a 4-level Likert scale from 1 – 'completely disagree' to 4 – 'completely agree').

2.3. Procedure

The experiment was conducted individually using a computerized procedure. The first step was to complete the FCB-TI questionnaire. Then, we conducted the first measurement of the current emotional state (T1, pretest). In a questionnaire, the participants indicated their emotional state by measuring six basic emotions: anger, happiness, sadness, fear, disgust, and surprise (Ekman, 1992). Since the anger experience can be an embarrassing topic that triggers socially undesirable behaviors, we decided to introduce questions about other emotions to mask the true purpose of the research. On a scale of 1 to 100, participants rated the intensity of their currently experienced emotions.

In the subsequent step, anger was induced. Before the main task started, participants received false information that 83% of participants had succeeded in this task. Participants completed one trial of the task (duration: 1 min), which involved assessing the correctness of equations in different places on the screen with various time limits. The completion of the task was impeded by a blank screen that appeared a few times and a sound whose pitch varied. Participants received one point for each correctly evaluated equation. After three consecutive incorrect answers, their score was reset. The goal of the participant was to obtain and maintain 10 points until the end of the task. However, the procedure was designed (and previously tested in pilot studies) so that no one could accomplish this goal. After finishing the task, the measurement of the current emotional state was repeated (T2, induction phase).

In the next phase of the experiment, participants performed the task for one minute to launch a randomly assigned anger regulation strategy. The instructions for each strategy were:

1) Humor: *For the next minute, think about the funny side of your failure. How could you present the task you have just completed to make others laugh? What was humorous about the task or your behavior?*
2) Rumination: *For the next minute, think intensely about the failure you have just experienced. How did you feel?*
3) Distraction: *For the next minute, read the text that will be displayed on the screen. It doesn't matter whether you read the entire text or just a part of it. So, read at any pace.* The text displayed was neutral and concerned chimpanzees (encyclopedic description).
4) Downplaying: *For the next minute, try to mentally identify all the reasons why you shouldn't worry about failing these tasks.*

The last element of the experiment was the third measurement of the current emotional state (T3, regulation phase). At this point, a message explaining the true purpose of the study and the impossibility of successfully completing the task appeared on the screen. After the experiment had been completed, the experimenter displayed a short humorous video that aroused the respondents' positive affective state.

The Ethics Committee of the Faculty of Psychology of SWPS University of Social Sciences and Humanities accepted the project (opinion number: 1/2016).

3. Results

3.1. Preprocessing and statistical analyses

Both temperamental indicators, i.e., ER and EN, were standardized to obtain the SPC indicator using the following formula: SPC = (Z_EN − Z_ER) / 2 (see Jankowski & Zajenkowski, 2009). Analyses of the distribution of anger revealed moderately high skewness and kurtosis values, thus it was decided to apply square root transformation of these data (see: Tabachnick & Fidell, 2013).

All statistical analyses were conducted using the open-source R software (R Core Team, 2021) with additional packages: afex (Singmann et al., 2021) for multilevel modeling, emmeans (Lenth, 2021) for post-hoc follow up tests, and multcomp (Hothorn et al., 2008) for adjusted pairwise comparisons.

For data analysis we used linear mixed-effects models (Baayen et al., 2008). To make results easier to read, we present type III ANOVA tables based on the *Kenward-Roger approximation* (Halekoh & Højsgaard, 2014; Kenward & Roger, 1997), which is known to best control Type I errors in limited sample sizes and provides an estimate of denominator degrees of freedom.

To test our hypotheses, we conducted two separate random intercept mixed models on levels of anger using a full factorial design with experimental manipulation and time of measurement as categorical predictors, with SPC (first model) or EN and ER (second model) as continuous predictors for the fixed effects, and with a random intercept for each participant.[1] We present our results in the following order: first, we describe the model with SPC as a continuous moderator, focusing on effects pertaining to manipulation checks; then we describe the effects directly related to our hypotheses. Next, we describe the results of an alternative model, where SPC is modeled as a function of its two components: ER and EN.

4. Results

First, we sought to establish whether the anger induction manipulation had been successful. The effect of the manipulation was manifested in the main effect of time, which was significant $F(2, 464) = 124.17$, $p < .001$. Pairwise comparisons of estimated marginal means revealed that anger during the induction phase was higher than during the pretest phase ($\Delta_{T2\text{-}T1} = 2.23$, $t\,(464) = 17.76$, $p < .001$), and the regulation phase lowered anger levels ($\Delta_{T3\text{-}T2} = -1.18$, $t\,(464) = 8.01$, $p < .001$).

In line with our expectations, the main effect of time was additionally moderated by SPC, $F(3, 464) = 12.25$, $p < .001$, and the grouping factor, $F(6, 464) = 2.33$, $p = .032$.

As predicted, the pairwise comparison explaining the time × SPC interaction (Fig. 1) showed that the slope between anger and SPC in T2 was negative ($b = -0.87$, $SE = 0.174$) and was significantly different than the slope between SPC and anger in T1 ($b = 0.01$, $SE = 0.174$), $t\,(464) = 4.79$, $p < .001$. This indicates that people with lower SPC experience less anger after induction than people with higher SPC. It is worth noting that the slope of the effect of SPC on anger during the regulation phase (T3) was not different ($b = -0.64$, $SE = 0.174$) than the effect during the anger induction phase (T2) $t(464) = -1.32$, $p = .387$.

The interaction between time and SPC was not moderated by a higher-order interaction with group $F(6, 464) = 0.63$, $p = 705$.

The other time × group (Fig. 2) interaction revealed that the type of regulation strategy had an impact on anger levels. Pairwise follow-up analyses showed that (independently of SPC levels) the rumination strategy did not reduce anger in the regulation phase, ($\Delta_{T3\text{-}T2} = -0.33$) $t\,(464) = 1.10$; $p = .516$, as opposed to the other strategies (Distraction $\Delta_{T3\text{-}T2} = -1.19$; Humor $\Delta_{T3\text{-}T2} = -1.48$; Downplaying $\Delta_{T3\text{-}T2} = -1.73$, all $ps < .001$).

Additionally, within the tested model we also found a significant main effect of SPC, $F(1, 232) = 13.25$, $p < .001$, which shows an overall tendency to experience less anger with higher values of SPC (b = −0.51, SE = 0.139, $p < .001$). The main effect of group was not significant, $F(3, 232) = 0.38$, $p = .764$, and the group × SPC interaction was also not significant, $F(3, 84.71) = 0.50$, $p = .684$. This shows that SPC does not moderate the effectiveness of the different anger reduction strategies.

Next, we tested an alternative model in which both the components that constitute SPC, i.e. endurance (EN) and emotional reactivity (ER), were tested. We assumed that ER would have a greater impact on propensity for anger arousal than EN during the anger induction phase (T2). Moreover we expected that EN would manifest a stronger effect on anger

[1] Code wise model 1 was expressed as afex::mixed(anger ~ time * group * SPC + (1 | id)). Model 2 was expressed as afex::mixed(anger ~ time * group * EN * ER + (1 | id)).

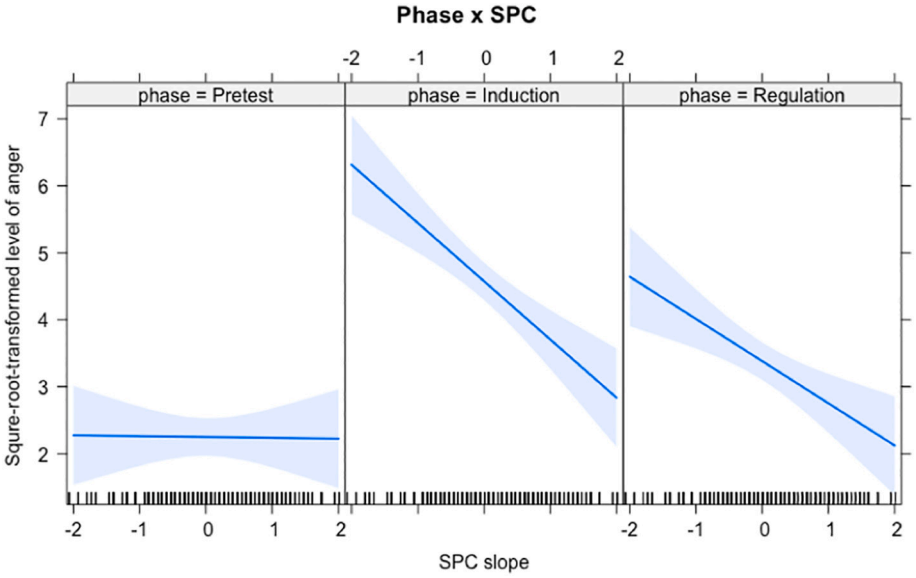

Fig. 1. Interaction of time and SPC. Values represent slopes between anger and SPC levels.

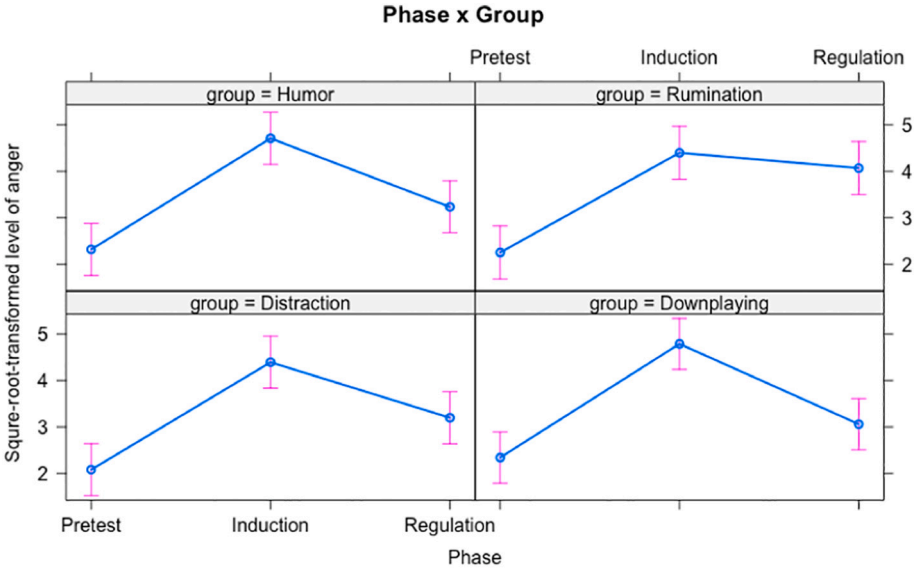

Fig. 2. Interaction of time and group. Values represent estimated marginal means of the square-root-transformed level of anger.

during the regulation phase.

As presented in Table 1, the interaction between phase and ER was significant. Follow-up comparisons showed that the relationship between ER and anger was positive and significant ($b = 0.73$, $SE = 0.17$) during the anger induction phase, meaning that people with higher ER experienced more anger after induction than they did during the pretest phase ($\Delta_{T2\text{-}T1} = 0.53$) $t(448) = 3.12$; $p = .001$. The interaction between phase and EN was also significant, but the relationship between EN and anger was negative ($b = -0.27$, $SE = 0.17$) during the anger induction phase. This shows that higher endurance leads to lower anger, as compared to its baseline level during the pretest phase ($\Delta_{T2\text{-}T1} = -0.44$) $t(448) = 2.50$; $p = .034$. As expected, the effect of ER on anger was greater ($b = 0.73$) than the effect of EN on anger ($b = -0.27$).

Contrary to our expectations, during the regulation phase the relationship between EN and anger was not significant ($b = -0.05$, $SE = 0.17$) and the relationship between ER and anger was similar to what we observed during the induction phase ($b = 0.70$, $SE = 0.17$).

The analysis also revealed a significant four-way interaction. In order

Table 1
Type III Anova tests for the effects of time and group, moderated by EN and ER, on anger.

Effect	df	F	*p* value
Group	3, 224	0.91	.438
Time	2, 448	97.79	<.001
EN	1, 224	0.16	.678
ER	1, 224	16.29	<.001
Group × time	6, 448	3.34	.003
Group × EN	3, 224	1.15	.330
Time × EN	2, 448	3.13	.045
Group × ER	3, 224	2.02	.112
Time × ER	2, 448	6.17	.002
EN × ER	1, 224	0	.946
Group × time × EN	6, 448	0.43	.861
Group × time × ER	6, 448	1.143	.201
Group × EN × ER	3, 224	1.91	.129
Time × EN × ER	2, 448	0.13	.882
Group × time × EN × ER	6, 448	2.84	.010

to decompose this interaction, we first examined the presence of the group × EN × ER interaction separately for each phase of our study. As expected, this effect was nonexistent during the pretest and induction phases (*ps* > .050), but it was found during the reduction phase $F(3, 472) = 3.81$, $p = .010$. To further investigate the moderating effect of EN × ER within every experimental condition, we dropped the pretest and reduction phases from our analyses. No manipulation occurred in these phases. Thus, we concentrated only on the reduction phase. A simple linear regression with three predictors (group × EN × ER) confirmed the presence of a higher-order interaction, $F(3, 224) = 3.80$, $p = .011$, which was further divided into two simple slope analyses. As presented in Fig. 3, for participants in the Rumination condition, the slope between anger and Emotional Reactivity was positive at high levels ($b = 1.73$, $SE = 0.43$, $p < .001$) of Endurance, but it was not significant at low levels of Endurance ($b = 0.09$, $SE = 0.33$, $p = .789$).

For participants in the Humor condition, the slope between anger and Emotional Reactivity was positive at both low and high levels of Endurance (b = 0.95, SE = 0.44, $p = .031$, b = 1.61, SE = 0.48, $p = .001$ accordingly). In the Distraction and Downplaying conditions, the relationships between anger and Emotional Reactivity were not significant for either Endurance level (*ps* > .05).

5. Discussion

Our study aimed to examine the function of SPC in two stages of the anger regulation process: vulnerability to anger arousal and reducing experienced anger by different regulative strategies. We examined humor, downplaying, distraction, and rumination.

We confirmed our hypothesis about the role of SPC in the propensity for anger: people with a lower level of SPC get angry more easily.

We observed that the effectiveness of anger regulation strategies differs. Rumination is substantially worse than the other techniques: it was the only strategy that did not reduce experienced anger. But rumination also did not increase anger arousal, as was hypothesized.

The expected moderating role of SPC in the effectiveness of anger regulation strategies was not also found. All strategies were generally more effective when a higher SPC level accompanied them. We suppose that all the examined strategies employ cognitive functions. Therefore, there were no differences among the strategies in the facilitation effect of SPC. However, our results expand the outcomes of Gilam et al.'s (2018) research, in which there was no control of the strategies applied by the participants. We provided evidence that SPC generally helps regulate anger, no matter which regulative strategy is used.

Our deeper analysis, which included EN and ER as separate factors, partially supported our hypotheses. We confirmed that ER has a greater impact than EN on vulnerability to anger induction. However, our expectation that we would observe a more significant role of EN in the regulation phase was not meet. ER was the critical factor for the level of anger in both the induction and regulation phases.

However, it was found that components of SPC (ER and EN) have different impacts on the effectiveness of specific regulative strategies. We observed that higher emotional reactivity leads people to a higher level of anger when applying the humor strategy. Some research shows (Scheibe et al., 2015) that greater intensity of anger does not favor strategies related to cognitive reappraisal. Of all the investigated strategies, humor seems to need the most significant cognitive effort. Thus, people with higher ER levels who respond to anger induction with greater anger could have problems applying this strategy.

The results also show that the effectiveness of rumination is not impaired if a person has a low EN level. We suppose that EN helps highly emotionally reactive people to hold on to the angry state.

5.1. Limitations

During the experiment, there was no control over the mental operations performed by the participants. Therefore, we do not know exactly what people did when they were asked to apply an anger regulation strategy. For example, they could have used additional strategies to regulate their anger experience. Moreover, following the processual model of emotion regulation (Gross, 2014), despite the cognitive commitment required by the anger-inducing task, the subjects could have already been using another strategy at this stage of anger

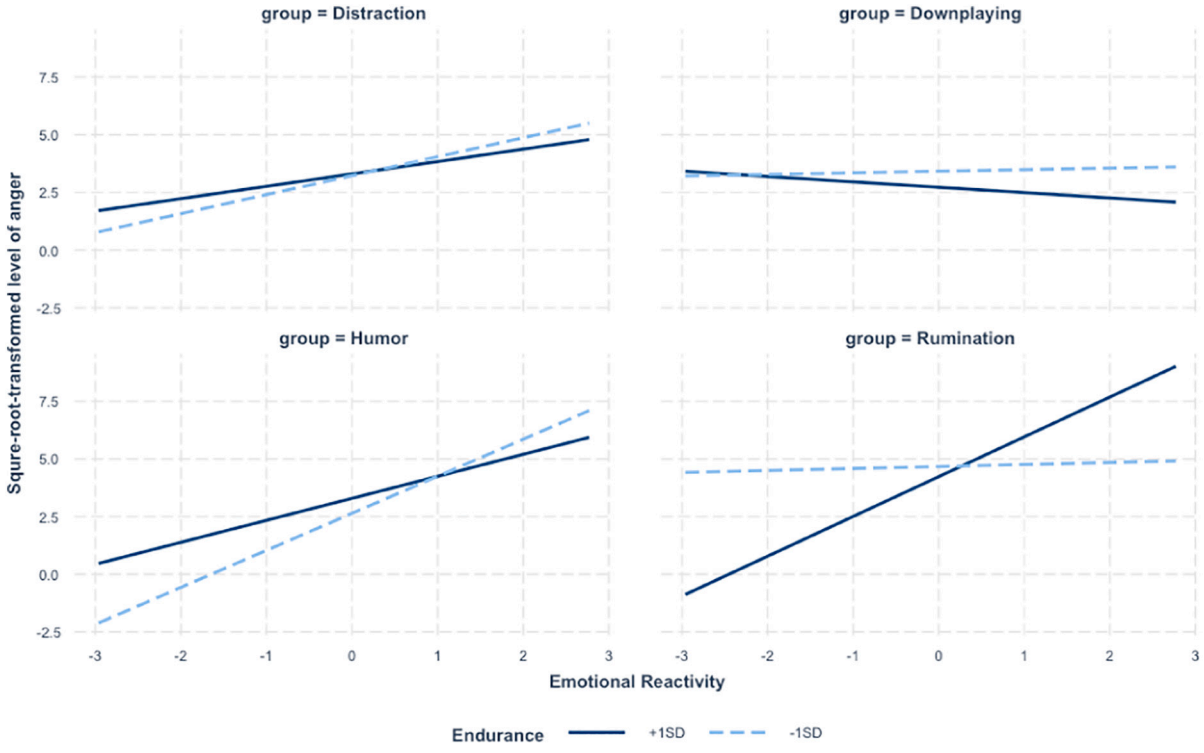

Fig. 3. Slopes between ER and anger, moderated by EN and group.

regulation.

The limitations of the SPC ratio should also be considered. Due to the linear combination of two variables, one value of this factor may reflect people with different temperamental characteristics.

CRediT authorship contribution statement

Agata Kozlowska: Conceptualization, Methodology, Writing – Original draft, Writing Review & editing, Project administration, Funding acquisition
Magdalena Marszał-Wiśniewska: Supervision, Conceptualization, Methodology
Jakub Niewiarowski: Formal analysis, Writing – Original draft
Błażej Mroziński: Formal analysis, Writing Review & editing, Visualisation.

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