Cognitive reappraisal capacity mediates the relationship between prefrontal recruitment during reappraisal of anger-eliciting events and paranoia-proneness

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A B S T R A C T

Difficulties in emotion regulation, particularly in using adaptive regulation strategies such as cognitive reappraisal, are a commonly observed correlate of paranoia. While it has been suggested that poor implementation of cognitive reappraisal in dealing with aversive events precedes the onset of subclinical paranoid thinking, there is little empirical research on neural activation patterns during cognitive reappraisal efforts that might indicate vulnerability towards paranoid thinking. Prefrontal EEG alpha asymmetry changes were recorded while n = 57 participants were generating alternative appraisals of anger-eliciting events, and were linked to a behavioral measure of basic cognitive reappraisal capacity and self-reported paranoia proneness (assessed by personality facets of hostility and suspiciousness: Personality Inventory for DSM-5). Mediation analysis revealed that less left-lateralized activation at ventrolateral prefrontal sites during reappraisal efforts predicted a higher degree of paranoia proneness. This relationship was mediated through poorer cognitive reappraisal capacity. Matching previous evidence, findings suggest that inappropriate brain activation during reappraisal efforts impairs individuals’ capacity to come up with effective alternative interpretations for anger-evoking situations, which may accentuate personality features related to increased paranoid thinking. The findings add to our understanding of neurally underpinned impairments in the capacity to generate cognitive reappraisals and their link to maladaptive personality and behavior.

1. Introduction

Emotion regulation difficulties are often considered crucial in elucidating individual differences in personality disorders and associated subclinical traits (Dimaggio et al., 2017; Garofalo et al., 2018; Velotti et al., 2016). In spite of that, some maladaptive personality features and their link to emotion regulation have received only little empirical attention to date, in both general population and clinical samples. Among these previously rather neglected personality features is the propensity to paranoid thinking, which is often described as a trait-like suspicious hostility (e.g., Falkum, Pedersen, & Karterud, 2009; Lee, 2017; Savulich, Freeman, Shergill, & Yiend, 2015; Triebwasser, Chemerinski, Roussos, & Siever, 2013) and is considered almost as prevalent as symptoms of anxiety and depression in the general population (Freeman et al., 2005, 2008). Based on notions that difficulties in adaptive emotion regulation may precede the emergence of paranoid symptoms (Fowler et al., 2012; Krkovic, Krink, & Lincoln, 2018; Westermann, Boden, Gross, Lincoln, 2013), the present study employed mediation analysis to examine whether a reduced brain-based capacity to generate cognitive reappraisals for situations implicating harmful behavior of another person may be linked to increased paranoia proneness in a non-clinical sample.

1.1. Emotion regulation difficulties and paranoid thinking

Per definition, paranoid thinking denotes false beliefs that others harbor malevolent or harmful intentions towards oneself (Freeman & Garety, 2014; Freeman, Garety, & Phillips, 2000). These false beliefs
about imminent threat from others presumably reinforce feelings of mistrust and anger, which may accumulate to aggressive behavior (Darrell-Berry et al., 2017; Tone & Davis, 2012). This partially implies that anger-eliciting situations may be particularly relevant to the emergence of paranoid thoughts (Darrell-Berry et al., 2017; Yamauchi, Sudo, & Tanno, 2009). More broadly, a number of studies have identified emotion regulation difficulties in individuals with various levels of paranoid thinking up to persecutory ideation (Dimaggio et al., 2017; Garofalo et al., 2018; Moritz et al., 2016; Westermann & Lincoln, 2011) and part of this research emphasized burdened individuals’ tendencies to employ specific (mal)adaptive strategies for affect regulation. Here, studies with clinical samples need to be distinguished by their focus on paranoia in psychosis (e.g., Livingstone, Harper, & Gillanders, 2009; Moritz et al., 2016; Nittel et al., 2018) and paranoia in paranoid personality disorder (e.g., Dimaggio et al., 2017; Salvatore, Russo, Russo, Popolo, & Dimaggio, 2012). Yet, most of these studies concur in that deficits in adaptive emotion regulation strategies may antedate and exacerbate clinically relevant paranoid symptoms. Interestingly, this link between emotion regulation difficulties and paranoid thinking seems to hold for subclinical populations as well (paranoid personality: Garofalo et al., 2018; delusion-proneness: Krkovic et al., 2018; Martinelli, Cavanagh, & Dudley, 2013; Westermann, Rief, & Lincoln, 2014). Evidently, it is important to distinguish clinical levels of paranoia from the trait “paranoid thinking” in the general population (i.e., suspicious hostility; Falkum et al., 2009; Triebwasser et al., 2013). However, the continuum view of paranoia portends that many characteristics in cognition and emotion that are present in patients can, at attenuated levels, also be found in non-clinical individuals in response to everyday situations (Freeman, Pugh, Vorontsova, Antley, & Slater, 2010, also see Combs, Michael, & Penn, 2006; Combs, Finn, Wohlfahrt, Penn, & Basso, 2013). Thus, it is reasonable to assume that difficulties in implementing specific emotion regulation strategies may reinforce paranoid thinking and, thus, may accentuate related traits in non-clinical samples.

1.2. Cognitive reappraisal and paranoid thinking

One emotion regulation strategy assumedly relevant to paranoid thinking is cognitive reappraisal (e.g., Westermann, Kesting, & Lincoln, 2012), which involves deliberately re-interpreting a critical situation in a way that alters its emotional impact (e.g., Gross & John, 2003; Lazarus & Folkman, 1984). An inverse relationship of paranoid thinking with the capacity to successfully implement cognitive reappraisal seems likely, as effective reappraisal of aversive events requires a flexible shift from negative to more neutral or even positive situational perspectives (Joormann & Gotlib, 2010; Malooly, Genet, & Siemer, 2013). This process is diametrically opposed to the pervasive negative interpretation bias that constitutes a core feature of paranoid thinking (Freeman, 2007; Savulich et al., 2015). While similar proposals exist in literature, empirical research on the link between cognitive reappraisal and paranoid thinking is still sparse. In this context, Westermann et al. (2012) reported difficulties in effective reappraisal implementation in individuals with high paranoia proneness, a finding inferred from positive correlations between self-reported habitual reappraisal use and paranoid thinking following social exclusion. This finding partly suggests that failure to effectively implement cognitive reappraisal in critical situations may support paranoid thoughts (also see Westermann et al., 2014). However, this idea has never been explicitly tested to date. The present study was interested in a specific directional pathway leading from individuals’ capacity to generate alternative appraisals for upsetting events to increased paranoia proneness. We specifically scrutinized this relationship in the context of anger-eliciting interpersonal events. Overall, we sought to test a model that regards (reduced) cognitive reappraisal capacity as an antecedent, and not a consequence of paranoia proneness. While this may contrast with more traditional views that see emotion regulation difficulties as a natural consequence of paranoid states (e.g., Birchwood, 2003), the idea that emotion regulation difficulties precede paranoid thoughts is increasingly supported by research (e.g., Fowler et al., 2012; Krkovic et al., 2018; Westermann et al., 2013; van der Velde et al., 2015; for findings on psychosis, see Smeets et al., 2012). In this regard, the longitudinal investigations of Fowler et al. (2012) and Westermann et al. (2013) reported that maladaptive emotion regulation and negative cognition at baseline predicted paranoid symptoms months later, with Fowler et al. (2012) finding no evidence for a reverse pathway.

Investigating the relationship of cognitive reappraisal and paranoid ideation in the context of anger in interpersonal events is highly relevant, since anger inherently entails attribution of hostile intent and blame towards others, which is also intrinsic to paranoid thinking and may likely reinforce it (Freeman, 2007; Yamauchi et al., 2009). In line with this, Yamauchi et al. (2009) found that feelings of anger significantly increased individuals’ susceptibility to paranoid thoughts, but not vice versa. By implication, it is conceivable that especially when confronted with anger-eliciting interpersonal events, a poor capacity to activate positive situational re-interpretations over time could reinforce a specific negative interpretation bias in terms of more hostile and suspicious attributions. Surprisingly, although anger is a recognized correlate of paranoia (Darrell-Berry et al., 2017; Ellett, Lopes, & Chadwick, 2003; Thewissen et al., 2011), the link between cognitive reappraisal difficulties in the face of anger and paranoia proneness has received little attention to date.

1.3. The ability for cognitive reappraisal as a brain-based capacity

The idea of reappraisal difficulties facilitating paranoid thoughts becomes more intuitive if the process of cognitive reappraisal is quantified by what individuals can do at their best when instructed to spontaneously invent different cognitive re-interpretations for relevant situations (maximum performance, Cronbach, 1970). The capacity for cognitive reappraisal generation as measured by the Reappraisal In-ventiveness Test (RIT; Weber, Assunção, Martin, Westmeyer, & Geisler, 2014) is considered basic or fundamental, as it delineates an individuals’ basic cognitive potential to construct different interpretations for given situations (i.e., a construction competence). This theoretical ability to invent manifold reappraisals in critical situations putatively serves as a prerequisite for effective reappraisal implementation in daily life (Weber et al., 2014; Perchtold et al., 2018, 2019). This is most relevant when individuals face new situations that exceed their routines and cannot rely upon their habitually used reappraisal strategies (Weber et al., 2014). In this case, having a broad repertoire of potential reappraisals readily available increases the likelihood of selecting a reappraisal best suited to downregulate negative emotions in a specific context (Perchtold et al., 2019). Note that this performance approach to reappraisal is decidedly different from measuring individuals’ perceived efficacy in using reappraisal (e.g., Goldin et al., 2012) or self-reported success of reappraisal efforts (McRae, 2013), for which it may serve as a necessary, but not a sufficient prerequisite. Cognitive reappraisal capacity in the RIT is also uncorrelated with the habitual use of reappraisal in daily life (Weber et al., 2014), indicating that regular use of reappraisal does not automatically entail greater capacity to implement reappraisal and vice versa (Perchtold et al., 2019).

The argument that cognitive reappraisal capacity indicates an individuals’ basic cognitive potential for flexible coping with daily challenges is corroborated by findings that reappraisal efforts during the RIT recruited relevant brain regions in the prefrontal cortex (Papousek et al., 2017; Perchtold et al., 2018). Specifically, more relative left-lateralized activation at ventrolateral prefrontal sites during reappraisal attempts (assessed by EEG alpha asymmetry) was associated with a greater number and diversity of generated reappraisals in the RIT (Papousek et al., 2017). This matched previous EEG findings of more left-lateralized frontal activation during general reappraisal efforts (Choi, Sekiya, Minote, & Watanuki, 2016). Conversely, again in the
context of the RIT, absence of this lateralized frontal activation pattern during reappraisal efforts not only predicted reduced reappraisal capacity, but also more distal outcomes such as increased chronic stress perception in daily life (Perchtold et al., 2018). These effects were found for anger regulation in particular and together, denote cognitive reappraisal generation in the RIT as a fundamental, brain-based capacity with implications for well-being. These findings also coincide with a number of fMRI studies that were not directly concerned with hemispheric asymmetry, but confirmed the importance of lateralized, left ventrolateral prefrontal recruitment for successful cognitive reappraisal in terms of greater affect-reducing effects (e.g., Dillon & Pizzagalli, 2013; Ochsner, Silvers, & Buhle, 2012). Absence of a clear left-lateralized ventrolateral and as a result, more bilateral prefrontal activation during reappraisal efforts was shown in depressed adolescents and adults, signaling reduced reappraisal success (Johnstone, van Reekum, Urry, Kalin, & Davidson, 2007; for a similar finding in older adults, see Opitz, Rauch, Terry, & Urry, 2012). Similarly, reduced activation of the left ventrolateral cortex during reappraisal in patients with mood and anxiety disorders compared to controls was reported in a recent meta-analysis (Picó-Pérez, Radua, Steward, Menchón, & Soriano-Mas, 2017). Cognitive reappraisal also specifically recruited left ventrolateral prefrontal cortex when compared with other strategies such as expressive suppression or distraction (e.g., Dörfel et al., 2014; Price, Paul, Schneider, & Siegle, 2013). Importantly, inappropriate recruitment of the left ventrolateral prefrontal region during reappraisal attempts was also found in individuals with ultra-high risk for psychosis when compared to healthy controls (van der Velde et al., 2015).

1.4. The present study

Based on previous research that found left-lateralized activation of the lateral prefrontal cortex an important basis of cognitive reappraisal capacity (Papousek et al., 2017; Perchtold et al., 2018), the purpose of this study was to determine whether a reduced brain-based capacity to generate alternative appraisals for anger-eliciting events may be linked to personality features indicating increased paranoid thinking (hostility, suspiciousness). EEG alpha asymmetry changes were used to map potentially relevant neural activation patterns during reappraisal efforts, since this measure specifically targets the putatively important lateralized nature of neural activation, especially regarding cognitive reappraisal capacity in the RIT (Papousek et al., 2017; Perchtold et al., 2018). This approach is based on the assumption that inter-individual differences in the direction and magnitude of changes in frontal EEG alpha asymmetry in response to specific demands indicate an individual’s capability or typical mode to adapt to these very demands (Coan, Allen, & McKnight, 2006; see also Papousek et al., 2018). Also following relevant research background (Papousek et al., 2017; Perchtold et al., 2018), the analyses in the present study focused on the ventrolateral prefrontal electrode positions F7 and F8. Mediation analysis was used to test a biologically oriented model of paranoia proneness, with paths from EEG alpha asymmetry changes at this site to cognitive reappraisal capacity and from cognitive reappraisal capacity to paranoia proneness. Altogether, it was hypothesized that less left-lateralized brain activation in the ventrolateral prefrontal region during efforts to reappraise anger-eliciting interpersonal scenarios is related to paranoia proneness as indicated by hostility and suspiciousness in the Personality Inventory for DSM-5. Further, this relationship should be mediated by a lower capacity to generate effective reinterpretations for anger events in the RIT.

2. Material and methods

2.1. Participants

Using G*Power, the required sample size was estimated a priori ($\alpha = 0.05$, $1 - \beta = 0.80$). Effect sizes observed in previous relevant research ($f^2 = 0.10$ to 0.15; Fink et al., 2017; Papousek et al., 2017; Perchtold et al., 2018) suggested a minimum of 55 participants ($f^2 = 0.15$). Individuals were included in the study if they reported no neuropsychiatric disease or using psychoactive medication and no previous experience with the contents of the used test material. Out of sixty interested individuals, one was not tested because of antidepressive medication, one had participated in an experiment with the RIT before and one failed to show up at the agreed appointment. The final study sample comprised 57 participants (46 female, 11 male) in the age range between 18 and 39 years ($M = 23.3$, $SD = 5.3$). All participants were university students enrolled in various fields. Right-handedness was assessed by a standardized hand skill test (Steiniger, 2010). Participants were requested to refrain from alcohol for twelve hours and from coffee and other stimulating beverages for two hours prior to their lab appointment. Written informed consent was obtained, and students received course credit for participation in the EEG study. The study was approved by the authorized ethics committee.

2.2. Reappraisal inventiveness test

The RIT (Weber et al., 2014) consists of four items that confront individuals with anger-eliciting, everyday situations they can easily imagine happening to them and that require the generation of alternative appraisals in order to downregulate the experienced negative emotions. In line with cognitive emotion theories, these situations depict harmful behavior of another person, while at the same time, they are ambiguous on whether this behavior occurs willingly or carelessly. In the plant item of the RIT, for instance, participants face the situation of arriving back home after a vacation and finding all plants dead, although a friend agreed to water them (for full description, see Weber et al., 2014; p. 360). Items are supplemented by matching photographs in order to make the depicted situations more vivid. For the purpose of this study, four additional items were added that matched the main characteristics of the original ones (see Papousek et al., 2017; Perchtold et al., 2018). Each vignette was presented on a computer screen for 20 s. Participants were instructed to imagine the situation happening to them and to generate as many different ways as possible to think about or appraise the situation in a way that diminishes anger. They were instructed to press a button whenever they became aware of a new appraisal and to vocalize the idea concisely in one or two short sentences immediately after pressing the button. Then they were asked to press the button again, and the task was resumed until the allotted time of 3 min had elapsed. In doing so, EEG segments related to the production of reappraisals could be separated from segments contaminated with the production of speech. This protocol proved to be successful in previous relevant research (Fink, Benedek, Grabner, Staudt, & Neubauer, 2007; Papousek et al., 2017; Perchtold et al., 2018). Participants’ vocal responses were audiotaped for later analysis, and adherence to the protocol was carefully monitored. See Fig. 1 for a schematic representation of one item of the RIT. Subjective anger ratings in which participants rated the anger they would experience when confronted with the depicted situations indicated that all items were perceived as anger evoking (7-point scales ranging from 0 “not angry at all” to 6 “very angry”; $M = 3.65$, $SD = 0.89$).

2.3. EEG recording and quantification

EEG was recorded according to the international 10–20 system, using a Brainvision BrainAmp Research Amplifier (Brain Products) and a stretchable electrode cap, referenced to the nose and re-referenced offline to a mathematically averaged ears reference (Hagemann, 2004). Impedance was kept below 5 kΩ for all electrodes. EOG measures were obtained for identification of ocular artifacts. All data were inspected visually, in order to eliminate intervals in which ocular or muscle artifacts occurred. EEG was recorded during a 2-min resting period (eyes closed, participants were instructed to first rest their eyes on a filled
green circle on the screen and then imagine this circle with closed eyes), and during the RIT. For the assessment of EEG asymmetry during the RIT, only the time frames in which participants were mentally generating alternative appraisals were used, that is, reading and speaking intervals were excluded. Power spectra (epoch length 1 s, overlapping 50%, Hanning window) were averaged across all artefact-free intervals for an individual. Following the common approach in the field, power within the alpha frequency band (8–12 Hz) was used for the analyses.

Laterality coefficients (LC) were computed for the relevant electrode pair over the ventrolateral prefrontal region as LC = (R − L)/(R + L) × 100, where R denotes alpha power at F8 and L denotes alpha power at F7. The range of LC is confined to −1 to + 1, which makes the meaning of scores intuitive. In the physiologically expectable range of relative differences between the EEG alpha power at two homologous electrodes, LC is equivalent to the metric (lnR − lnL), see Papousek et al. (2018) and Allen, Coan, and Nazarian (2004, Fig. 3). Following the common approach in EEG alpha asymmetry research, we interpret relatively lower alpha power in one hemisphere than the other as relatively greater cortical activity in this hemisphere (see Allen et al., 2004 for a review of evidence and Harmon-Jones, 2006; Michels et al., 2010; Scheeringa et al., 2011 for recent experimental research supporting the assumption that EEG alpha band activity obtained in time frames of several seconds or minutes is inversely related to cortical activity). Thus, positive values indicate higher alpha activity in the right than in the left hemisphere (i.e., less relative right hemisphere cortical activity).

Following previous research in the context of reappraisal ability (Perchtold et al., 2018), specifically obtaining EEG alpha asymmetry changes in response to the demand of generating cognitive reappraisals, residualized change scores of alpha asymmetry at positions F7/F8 during the generation of reappraisals adjusted for the asymmetry in resting conditions were calculated (see also Papousek et al., 2018, 2014). This was done by linear regressions using LC during the resting condition to predict LC during the reappraisal task. Residualized change scores were used to ensure that the analyzed residual variability was due to the state-dependent activation while participants attempted to generate reappraisals, and not to individual differences in baseline levels (i.e., to general inter-individual differences irrespective of the contextual demand), and to control for measurement error inherent in the use of repeated measures of the same kind (e.g., Linden, Earle, Gerin, & Christenfeld, 1997; Steketee & Chambless, 1992).

2.4. Cognitive reappraisal capacity

Participants’ responses to the items of the RIT were used for the assessment of their cognitive reappraisal capacity in terms of the inventiveness in generating alternative appraisals of anger-eliciting events. In line with the standardized scoring procedure of the RIT (Weber et al., 2014), RIT-Fluency scores were obtained as the total number of generated non-identical cognitive reappraisal ideas (aggregated across all items), and were used as index of an individual’s reappraisal capacity in the statistical analyses. Examples for valid reappraisal ideas for the plant item are “A good opportunity to buy new, more beautiful plants” (individual with low paranoia proneness) or “Perhaps she did not want to do it from the beginning, but there is no way I

Fig. 1. Schematic representation of the Reappraisal Inventiveness Test (RIT).
could have known that” (individual with high paranoia proneness). The RIT also offers the possibility to analyze RIT-flexibility, which refers to the number of categorically different reappraisals (for the category scheme, see Weber et al., 2014). However, RIT-fluency and RIT-flexibility indicate nearly identical measures of cognitive reappraisal capacity, which is evident in their extremely high correlation (this study: \( r = 0.94, p < .001 \); and see Papousek et al., 2017; Rominger et al., 2018; Weber et al., 2014, where similar correlations were reported). This redundancy likely originates from test instructions to invent as many categorically different reappraisals as possible within a limited amount of time, which inherently maximizes both scores (Weber et al., 2014). For similar reasons, it is often proposed in literature that verbal flexibility also supported by highly similar correlations of RIT-Fluency and RIT-Flexibility with in non-emotional divergent thinking tasks (\( r = 0.55 \) to \( 0.59 \); Weber et al., 2014). Thus, the analyses of this study focus on RIT-Fluency only. Two experimenters independently rated participants’ reappraisal ideas. Inter-rater reliabilities with two-way random, single measure ICC (95% confidence intervals, consistency) were ICC = 0.94 for RIT-fluency, and ICC = 0.89 for RIT-flexibility. Mean RIT-fluency score was \( M = 34.6 \) (SD = 14.7), mean flexibility score was \( M = 25.7 \) (SD = 9.0), which corresponds to previous EEG studies using this version of the RIT (e.g., Papousek et al., 2017; Perchtold et al., 2018). Internal consistency reliabilities (Cronbach’s alpha) were \( \alpha = 0.93 \) (RIT-fluency) and \( \alpha = 0.90 \) (RIT-flexibility).

2.5. Personality features related to paranoia proneness

The Personality Inventory for DSM-5 (PID-5, German version, Zimmermann et al., 2014) was used to obtain measures of personality features implicating increased paranoid thinking. The PID-5 is a 220-item questionnaire that assesses maladaptive personality traits according to the DSM-5 trait model (Section III, Emerging Measures and Models, Criterion B; Krueger, Derringer, Markon, Watson, & Skodol, 2012; Krueger & Markon, 2014). Items are rated on four-point Likert scales, from 0 (“very false”) to 3 (“very true”). The PID-5 captures five broad personality domains and 25 specific personality facets. Accordingly to the research question of this study, two specific facet scales were used: hostility (\( M = 0.85 \), SD = 0.45, \( \alpha = 0.77 \)) and suspiciousness (\( M = 0.93 \), SD = 0.46, \( \alpha = 0.76 \)). These two characteristics were among the most prominent proposed criteria for paranoid personality disorder in the DSM-IV (American Psychiatric Association, 1994), and the facet scales showed substantial correlations (\( r = 0.51 \), \( r = 0.62 \)) with a self-report measure of paranoid personality disorder according to DSM-IV criteria (Hopwood, Thomas, Markon, Wright, & Krueger, 2012). In light of significant correlations between the two facets in the present study (\( r = 0.47, p < .001 \)), a composite measure of paranoia proneness was computed by aggregating the z-standardized scores for hostility and suspiciousness (for a similar approach, see Cicero & Kerns, 2011; Combs, Penn, Wicher, & Waldheter, 2007; Tiegreen & Combs, 2017). Importantly, domain but also facet scores of the PID-5 exhibit adequate variability and validity in non-clinical community and student samples with scores in the lower ranges of the scales (e.g., Bastiaens, Smits, De Hert, Vanvalleghem, & Claes, 2016; de Fruyt et al., 2013; Papousek et al., 2018).

2.6. Procedure

After completing the handedness test, participants were seated in an acoustically and electrically shielded examination room. Electrodes were attached and participants were instructed to relax and adapt to the surroundings. Subsequently, the EEG was recorded during an initial 2-min resting period. Then the participants were instructed for the task and were given a practice item. After completing the RIT (while the EEG was again recorded), electrodes were detached, and the participants were given the opportunity to wash and dry their hair. Finally, they completed the PID-5.

2.7. Statistical analysis

In a first step, Pearson’s correlations were computed to test whether brain activation at ventrolateral prefrontal sites during efforts to generate cognitive reappraisals of anger-eliciting situations (EEG alpha asymmetry changes at positions F7/F8) was associated with the capacity for cognitive reappraisal generation (RIT fluency score) and paranoia proneness (composite score of PID-5 facets hostility and suspiciousness) in the expected directions. Mediation analysis was conducted using the SPSS macro PROCESS (Hayes, 2013), to examine the potential mediating role of cognitive reappraisal capacity in the relationship between brain activation pattern during the attempt to generate cognitive reappraisals and proneness to paranoid thinking. The analysis was based on 5000 bootstrapping samples, and biases were corrected at 95% confidence intervals (CI) to estimate the indirect effects. If the CI of the indirect effect does not include zero, the indirect effect is considered to be significant (\( p < .05 \)). This bootstrapping method appears to be more appropriate than other tests of indirect effects (e.g., Sobel tests), as it does not require multivariate normality or estimated standard errors (Preacher & Hayes, 2008). The effect of the independent variable (EEG alpha asymmetry changes during reappraisal generation) is displayed in the total effect; when controlling for the mediator variable of cognitive reappraisal capacity (RIT), it is indicated in the direct effect. The indirect effect comprises the path over cognitive reappraisal capacity.

3. Results

Individuals with relatively greater left-lateralized activation at ventrolateral prefrontal sites while generating reappraisals displayed a greater capacity for cognitive reappraisal generation in terms of higher reappraisal inventiveness (\( r = 0.28, p = .033 \)). Further, individuals showing less left versus right sided activation at that site during reappraisal generation reported higher proneness to paranoia (\( r = −0.39, p = .003 \)). Higher paranoia proneness was also associated with poorer reappraisal capacity (\( r = −0.40, p < .001 \)).

The relationship between less left-lateralized brain activation at ventrolateral prefrontal sites during cognitive reappraisal and paranoia proneness was mediated by poorer cognitive reappraisal capacity, as indicated by a significant indirect effect of EEG alpha asymmetry changes on paranoia proneness via cognitive reappraisal capacity (\( B = −0.20, 95\% CI = −0.407 \) to −0.010). See Table 1 and Fig. 2 for

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1 Participants completed the entire PID-5. However, since we had specific a priori hypothesis only about facets that prominently reflect paranoid thinking (hostility, suspiciousness), and did not want to take an undirected, exploratory approach to our data, relationships of other PID-5 personality facets with brain-based cognitive reappraisal capacity were not analyzed and are thus not reported.

2 After running the originally hypothesized mediation model, as part of a sensitivity analysis, alternative mediation models were tested that considered paranoia proneness as the independent variable, in light of more traditional assumptions that a more or less stable personality trait may rather predict indices of cognitive reappraisal (e.g., Birchwood, 2003). This allowed us to rule out potentially plausible alternative explanations for the observed correlations. This way, we followed suggestions that a specific mediation claim is stronger if plausible alternative explanations do not hold (see Agler & De Boeck, 2017). These additional analyses are reported in the supplementary material to this article.

3 Running the model with reappraisal-flexibility yielded similar results, as did
a summary of the mediation results.

4. Discussion

Research increasingly portends that emotion regulation difficulties may play a role in the development and maintenance of paranoid thinking (Fowler et al., 2012; van der Velde et al., 2015; Westermann et al., 2013). Based on this premise, the present study investigated specific directional pathways from state-dependent EEG alpha asymmetry changes in the prefrontal cortex during cognitive reappraisal efforts and the resulting capacity for cognitive reappraisal generation to paranoia-related personality features (hostility, suspiciousness). Mediation analysis supported this biological model of paranoia proneness: Less left-lateralized activation at ventrolateral prefrontal sites during attempts to invent alternative appraisals for anger-eliciting interpersonal situations was associated with personality traits indicating proneness to paranoia; and this relationship was mediated by lower cognitive reappraisal capacity. Accordingly, the following tentative interpretation is suggested: Failure to increase relative left vs. right sided activation at ventrolateral prefrontal sites during cognitive reappraisal efforts may impair individuals’ capacity to come up with effective, alternative interpretations for anger-evoking interpersonal situations and this impaired capacity may partly contribute to increased paranoid ideation.

Studies in clinical populations already discussed links between attenuated activation of left ventrolateral prefrontal areas during cognitive reappraisal efforts and negative outcomes (e.g., depression; Johnstone et al., 2007; Picó-Pérez et al., 2017). In a student sample, Perchtold et al. (2018) underlined broader consequences of less left-lateralized activation of this prefrontal region in terms of psychological well-being, finding this activation pattern during reappraisal efforts indicative of greater chronic stress experience. Notably, several manifestations of stress, ranging from mild experimental induction to trauma, are closely related to paranoid thinking, particularly suspiciousness (e.g., Lincoln, Peter, Schäfer, & Moritz, 2009; Loewy et al., 2019). In this regard, the present study may add additional insights into the practical relevance of left vs. right ventrolateral prefrontal recruitment during reappraisal efforts and the resulting reappraisal capacity by demonstrating effects on a further more distal outcome. As regards paranoid thinking specifically, this study’s results are also supported by van der Velde et al. (2015), who, though not directly concerned with hemispheric asymmetry, observed reduced activation in the left ventrolateral prefrontal region during reappraisal efforts in individuals at risk for psychosis. The authors suggested that cognitive reappraisal difficulties underpinned by this activation pattern might result in higher proneness to paranoid and psychotic thinking. In sum, the current results that inappropriately lateralized prefrontal brain activation during reappraisal efforts may support paranoid personality features denotes a novel avenue in relevant research. However, this argument, made from a neurophysiological perspective, is in line with Fowler et al. (2012), with these authors proposing that the most plausible models for the relationship between affect, negative cognition and paranoia were the ones with direct paths from emotion dysregulation to paranoia and not vice versa. In addition, our findings concur with proposals of Westermann et al. (2012, 2014), who similarly modelled potential pathways from failed reappraisals in critical situations to an increase in paranoid thinking.

More generally, the effects in this study constitute a successful replication of previous findings that linked lower capacity for cognitive reappraisal in the RIT to relatively less left-lateralized activation at ventrolateral prefrontal sites during reappraisal efforts (Papousek et al., 2017). This finding further corroborates the crucial role of this prefrontal region in reappraisal of adverse events (e.g., Choi et al., 2016; Dillon & Pizzagalli, 2013; Kalisch, 2009; Ochsner et al., 2012, Phan et al., 2005). It also supports the basic notion in laterality research that functional deficits ensue if brain regions on which specific functions depend on are inadequately activated (e.g., Davidson, Chapman, Chapman, & Henripres, 1990; Gur et al., 1994; Papousek & Schulte, 2004; Papousek et al., 2017; Wendt & Risberg, 1994). Importantly, note that while these previous as well as the present findings contend the importance of left-lateralized frontal activity in cognitive reappraisal generation, they do not dispute that right prefrontal regions also figure prominently in the top-down regulation of negative affect (e.g., Falquez et al., 2014; Ochsner et al., 2004, 2012). Here, the crucial difference

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**Table 1** Summary of mediation analysis.

| Effect                                      | R² (p) | B    | SE  | p      | 95% CI          |
|---------------------------------------------|--------|------|-----|--------|-----------------|
| Lateralized brain activation during reappraisal efforts (F7/F8) – reappraisal fluency - paranoia proneness |        |      |     |        |                 |
| c                                           | 0.31 (< .001) | 0.204 | 0.107 | .041  | [−0.430 to −0.002] |
| a                                           | 4.20   | 1.923 | .033 |        |                 |
| b                                           | 0.05   | 0.14  | < .001 |        |                 |
| c'                                          | −0.47  | 0.204 | .024 |        |                 |
| ab                                          | −0.20  | 0.107 | .041 |        |                 |
| ab = −0.20*                                 |        |      |     |        |                 |

Note: c = total effect of EEG alpha asymmetry changes during reappraisal generation on paranoia proneness; a = effect of EEG alpha asymmetry changes on reappraisal fluency; b = effect of reappraisal fluency on paranoia proneness; c' = direct effects of EEG alpha asymmetry changes on paranoia proneness while adjusting for reappraisal fluency, ab = indirect effects of EEG alpha asymmetry changes on paranoia proneness through reappraisal fluency, R² = proportions of variance explained by the model, B = unstandardized beta weights; SE = standard errors; p = p-value; CI = confidence intervals (95%).

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Fig. 2. The mediation model. Capacity for cognitive reappraisal generation mediates the relationship between EEG alpha asymmetry in the ventrolateral prefrontal cortex (F7/F8) and paranoia proneness; p < .05.
between different experimental instructions for cognitive reappraisal likely becomes apparent. The performance-based, spontaneous generation of alternative reappraisal ideas in the RIT corresponds to divergent thinking (Weber et al., 2014) and thus putatively draws on different cognitive processes than downregulating negative affect by repeated implementation of only one or two reappraisal strategies (e.g., Ochsner et al., 2004). More precisely, counteracting negative affect with one suitable reappraisal may be mostly facilitated by the inhibition of dominant (affective) responses, which may be linked to activation of right frontal regions (Aron et al., 2004, 2010). The generation of manifold reappraisals, however, not only draws on response inhibition, but in addition, also requires cognitive switching between different situational perspectives and updating of cognitive sets and memory (e.g., Papousek et al., 2017). Activation of these processes have been primarily observed in left lateral prefrontal regions (e.g., Badre & Wagner, 2017; Capizzi, Ambrosini, Arbula, Mazzonetto, & Vallesi, 2016; Hirshorn & Thompson-Schill, 2006; Kim, Gilles, Johnson, & Gold, 2012). Accordingly, whether cognitive reappraisal efforts more strongly recruit left or right frontal areas putatively depends on how cognitive reappraisal is instructed and operationalized in experimental tasks (e.g., success, frequency, efficacy; McRae, 2013). Taken together, in line with previous research, our proposal of left-lateralized activation of the lateral prefrontal cortex as a crucial underpinning of cognitive reappraisal is specific to the capacity to invent manifold cognitive reappraisals for critical situations (Papousek et al., 2017; Perchtold et al., 2018).

The findings of this study were obtained in the context of cognitive reappraisal of anger-eliciting situations (see Papousek et al., 2017; Perchtold et al., 2018). Previous studies mostly focused on links between paranoia proneness and reappraisal difficulties in the face of anxiety-eliciting stimuli (Westermann et al., 2014). Yet, anger constitutes an eminently relevant context for the development of paranoid thoughts, especially if situations are ambiguous on whether harmful behavior of others occurred willfully or carelessly (Combs et al., 2013; Savulich et al., 2015). Accordingly, Savulich et al. (2015, 2017) proposed that tendencies to negatively interpret emotionally ambiguous information are most evident in paranoia prone individuals when faced with material that matches their paranoid concerns of others intending to cause harm. It seems likely that a reduced brain-based capacity to generate more positive situational interpretations in this case (e.g., that harm was not intended and the wrongdoer is generally a good person) leads to hostile and suspicious attributions (for the RIT plant item: “This friend was always jealous of my plants, what did I expect?”). These attributions, with repetition and over time, may contribute to the accentuation of paranoia-related personality features. In accordance, higher proneness to paranoia was associated with significantly less positive interpretations of ambiguous situational descriptions in a student and community sample (Savulich et al., 2015; for similar findings in depressed individuals, see Hindash & Amir, 2012). More generally, it was shown that a respective interpretation bias may become habitual over time (Everaert, Grahek, et al., 2017; Everaert, Podina, & Koster, 2017). Having cognitive reappraisal capacity predict paranoia-related personality features in the present study is noteworthy, since higher frequency and diversity of reappraisal ideas in the RIT indicate an individuals’ potential for cognitive flexibility in an affective context (Rominger et al., 2018; Weber et al., 2014). Previous literature suggested that impaired executive functions might serve to exacerbate paranoid interpretation bias: Particularly reduced cognitive flexibility results in difficulties to break from maladaptive patterns in information processing, including the inability to consider alternative situational interpretations and a strong tendency to jump to conclusions (Savulich et al., 2015; So et al., 2012). However, only two previous studies reported negative correlations between paranoia or paranoid interpretation bias and general cognitive flexibility, the latter of which assessed as a self-reported trait (Freeman et al., 2008; Savulich et al., 2015). Accordingly, although the present study is the first to use a cognitive reappraisal capacity measure to uncover links with paranoid thinking in a sub-clinical sample, our findings match pre-existing notions in literature.

Several limitations of this study should be acknowledged. Due to lack of respective mood assessments, it cannot be completely ruled out that the obtained relationship between less left ventrolateral frontal asymmetry and increased paranoia proneness were partly influenced by individuals’ negative emotionality at the time of measurement. While the actual experience of affective states is more strongly associated with the dorsolateral frontal region (e.g., Davidson, 2004; Ochsner & Gross, 2007), affect-related asymmetries were also observed anterior and ventral to this site (Lewis, Weeke, & Wang, 2007; Lopez-Duran, Nuslock, George, & Kovacs, 2012; Papousek & Schulter, 2002). Yet, it is highly unlikely that the found relationships are explained by individuals’ anger experience with the RIT. Given that angry states are consistently linked to more left-lateralized activation in the dorsolateral prefrontal region (e.g., Harmon-Jones, Gable, & Peterson, 2010), it would be absurd to assume that higher levels of anger with the RIT situations would facilitate greater cognitive reappraisal capacity and by implication, lower proneness to paranoid thoughts (for similar argumentation, see Papousek et al., 2017). Secondly, it may be considered that the elicitation of positive emotions and/or generation or positively toned reappraisals during reappraisal efforts influenced the observed relationship between left frontal asymmetry, reappraisal capacity and paranoia proneness. However, since we did not find evidence for such influences in our data, and based on previous research specifically focusing on processes related to reappraisal efforts in the RIT (Papousek et al., 2017; Perchtold et al., 2018), we favor the interpretation in terms of cognitive reappraisal capacity. Nevertheless, potential additional influences of positive emotions in the course of the reappraisal process are an interesting issue for further research. Next, while this study’s research background points to cognitive reappraisal deficits as a factor potentially aggravating paranoia-related personality features, the cross-sectional design of this study precludes claims of causality. The fact that our hypothesized model best fit our data and corroborated previous findings that brain-based reappraisal difficulties predate the onset of paranoid thinking (e.g., van der Velde et al., 2015) does not rule out the existence of reciprocal relationships (also see Fowler et al., 2012). Hence, longitudinal investigations will be invaluable to explore whether improvement of cognitive reappraisal capacity (e.g., through tailored interventions) can predict improvements in maladaptive personality functioning. Relatedly, cognitive reappraisal capacity as assessed by the RIT only covers a certain aspect of an individual’s ability to effectively implement cognitive reappraisal in critical situations and naturally, in order to gain benefits, individuals need to make use of this ability in daily life (Perchtold et al., 2018, 2019). Thus, future models will have to include other aspects of cognitive reappraisal (e.g., habitual use, perceived efficacy, etc.) to allow for a more comprehensive investigation of the relationship between cognitive reappraisal implementation and paranoia proneness. In addition, replication with more traditional questionnaires on paranoid thinking is warranted to strengthen the results of this study (but see Statham, Emerson, & Rowe, 2019). Importantly, in any case, this study does not advocate that inappropriate brain activation during cognitive reappraisal efforts of anger-eliciting events facilitates a paranoid personality disorder, but merely a more general proneness to paranoid thoughts, which may also occur in other maladaptive personality complexes (e.g., schizoid, obsessive–compulsive, Falkum et al., 2009). Accordingly, both our hypotheses and findings do not exclude that similar mechanisms and pathways related to brain activation in relevant demanding situations and cognitive reappraisal capacity may be found for other personal characteristics as well. Further, participants were recruited from a young student population and are, therefore, not fully representative of the wider population. Consequently, further studies with community samples are needed to confirm the generalizability of the results. Similarly, the findings should not be generalized to individuals with...
clinically relevant levels of paranoia. Lastly, the present study only emphasized anger-eliciting events. While anger-evoking interpersonal scenarios provide a highly relevant context for paranoid concerns and are simultaneously under-researched in literature (e.g., Darrell-Berry et al., 2017), anxiety-evoking events are closely linked to paranoid symptoms as well (Thewissen et al., 2011; Westermann et al., 2012).

Thus, an extension of the present findings to the context of anxiety regulation is warranted to examine the robustness of the results.

In conclusion, adding to the novel strand of research on cognitive reappraisal capacity (Fink et al., 2017; Papousek et al., 2017; Perchtold et al., 2018, 2019; Römering et al., 2018; Weber et al., 2014), the present study demonstrated that less left-lateralized activation at ventral prefrontal sites during efforts to generate alternative appraisals for anger-eliciting events indicated proneness to paranoid thinking, and that this process was mediated by poorer cognitive reappraisal capacity. These results suggest that an impaired basic neural capacity to invent alternative appraisals in the context of anger, in part, might potentially facilitate the development or aggravation of paranoia-related personality features. In light of increasing recognition that paranoid thoughts have a prevalence similar to symptoms of anxiety and depression (Freeman et al., 2005, 2008) and are strongly correlated with adverse treatment outcomes and depression (Darrell-Berry et al., 2017; Moritz, Görtz, McLean, Westermann, & Brodbbeck, 2017), it seems prudent to investigate the specific neural antecedents of paranoid ideation in a more comprehensive way.

Declaration of interests

None.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bandc.2019.04.001.

References

Agler, R., & De Boeck, P. (2017). On the interpretation and use of mediation: Multiple perspectives on mediation analysis. Frontiers in Psychology, 8, 1984. https://doi.org/10.3389/fpsyg.2017.01984.

Allen, J. J. R., Cown, J. A., & Nazarian, M. (2004). Issues and assumptions on the road from raw signals to metrics of frontal EEG asymmetry in emotion. Biological Psychology, 67, 183–218. https://doi.org/10.1016/j.biopsycho.2004.03.007.

American Psychiatric Association (1994). Diagnostic and statistical manual of mental disorders (4th ed.). Washington, DC: Author.

Aron, A. R., Robbins, T. W., & Poldrack, R. A. (2004). Inhibition and the right inferior frontal cortex. Trends in Cognitive Sciences, 8, 170–177. https://doi.org/10.1016/j.tics.2004.02.010.

Aron, A. R., Robbins, T. W., & Poldrack, R. A. (2014). Inhibition and the right inferior frontal cortex: One decade on. Trends in Cognitive Sciences, 18, 177–185. https://doi.org/10.1016/j.tics.2013.12.003.

Badre, D., & Wagner, A. D. (2007). Left ventrolateral prefrontal cortex and the cognitive control of memory. Neuropsychologia, 45, 2863–2961. https://doi.org/10.1016/j.neuropsychologia.2007.06.015.

Bastiaans, T., Smits, D., De Hert, M., Vanваллелем, D., & Claes, L. (2016). DSM-5 section III personality traits and section II personality disorders in a Flemish community sample. Psychiatry Research, 238, 290–298. https://doi.org/10.1016/j.psychres.2016.02.056.

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References

Agler, R., & De Boeck, P. (2017). On the interpretation and use of mediation: Multiple perspectives on mediation analysis. Frontiers in Psychology, 8, 1984. https://doi.org/10.3389/fpsyg.2017.01984.

Allen, J. J. R., Cown, J. A., & Nazarian, M. (2004). Issues and assumptions on the road from raw signals to metrics of frontal EEG asymmetry in emotion. Biological Psychology, 67, 183–218. https://doi.org/10.1016/j.biopsycho.2004.03.007.

American Psychiatric Association (1994). Diagnostic and statistical manual of mental disorders (4th ed.). Washington, DC: Author.

Aron, A. R., Robbins, T. W., & Poldrack, R. A. (2004). Inhibition and the right inferior frontal cortex. Trends in Cognitive Sciences, 8, 170–177. https://doi.org/10.1016/j.tics.2004.02.010.

Aron, A. R., Robbins, T. W., & Poldrack, R. A. (2014). Inhibition and the right inferior frontal cortex: One decade on. Trends in Cognitive Sciences, 18, 177–185. https://doi.org/10.1016/j.tics.2013.12.003.

Badre, D., & Wagner, A. D. (2007). Left ventrolateral prefrontal cortex and the cognitive control of memory. Neuropsychologia, 45, 2863–2961. https://doi.org/10.1016/j.neuropsychologia.2007.06.015.

Bastiaans, T., Smits, D., De Hert, M., Vanваллелем, D., & Claes, L. (2016). DSM-5 section III personality traits and section II personality disorders in a Flemish community sample. Psychiatry Research, 238, 290–298. https://doi.org/10.1016/j.psychres.2016.02.056.

Birchwood, M. (2003). Pathways to emotional dysfunction in first-episode psychosis. The British Journal of Psychiatry, 182, 373–375. https://doi.org/10.1192/bjp.182.3.373.

Capizzi, M., Ambrosini, E., Arbula, S., Mazzonetto, I., & Vallesi, A. (2016). Electrophyysiological evidence for domain-general processes in task-switching. Frontiers in Human Neuroscience, 10, 124. https://doi.org/10.3389/fnhum.2016.00124.

Choi, D., Sesiya, T., Minote, N., & Watanuki, S. (2016). Relative left frontal activity in reappraisal and suppression of negative emotion: Evidence from frontal alpha asymmetry (FAA). International Journal of Psychophysiology, 109, 37–44. https://doi.org/10.1016/j.ijpsycho.2016.09.018.
and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*, 879–891.

Price, R. B., Paul, B., Schneider, W., & Siegle, G. J. (2013). Neural correlates of three neurocognitive intervention strategies: A preliminary step towards personalized treatment for psychological disorders. *Cognitive Therapy Research, 37*, 657–672. https://doi.org/10.1007/s10608-012-9508-x

Romer, C., Papoucek, I., Weiss, E. M., Schulte, G., Perchtold, C. M., Lackner, H. K., & Fink, A. (2018). Creative thinking in an emotional context: Specific relevance of executive control of emotion-laden representations in the inventiveness in generating alternative reappraisals of negative events. *Creativity Research Journal, 30*, 256–265. https://doi.org/10.1080/10400419.2018.1488196.

Salvatore, G., Russo, B., Russo, M., Popolo, R., & Dimaggio, G. (2012). Metacognition-oriented therapy for psychosis: The case of a woman with delusional disorder and paranoid personality disorder. *Journal of Psychotherapy Integration, 22*, 314. https://doi.org/10.1037/a0029577.

Savulich, G., Freeman, D., Shergill, S., & Yiend, J. (2015). Interpretation biases in paranoia. *Behavior Therapy, 46*, 110–124. https://doi.org/10.1016/j.beth.2014.08.002.

Savulich, G., Shergill, S. S., & Yiend, J. (2017). Interpretation biases in clinical paranoia. *Clinical Psychological Science, 5*, 985–1000. https://doi.org/10.1177/2167702617718180.

Scheerings, R., Fries, P., Peterson, K. M., Oostenveld, R., Grothe, I., Norris, D. G., & Bastiaansen, M. C. (2011). Neuronal dynamics underlying high- and low-frequency EEG oscillations contribute independently to the human BOLD signal. *Neuron, 69*, 572–583. https://doi.org/10.1016/j.neuron.2010.11.044.

Shao, Z., Jansé, E., Visser, K., & Meyer, A. S. (2014). What do verbal fluency tasks measure? Predictors of verbal fluency performance in older adults. *Frontiers in Psychology, 5*, 772. https://doi.org/10.3389/fpsyg.2014.00772.

Smeets, F., Lataster, T., Domínguez, M. D. G., Hommes, J., Lieb, R., Wittchen, H. U., & van Os, J. (2012). Evidence that onset of psychosis in the population reflects early hallucinatory experiences that through environmental risks and affective dysregulation become complicated by delusions. *Schizophrenia Bulletin, 38*, 531–542. https://doi.org/10.1093/schbul/sbq117.

So, S. H., Freeman, D., Dunn, G., Kapur, S., Kuipers, E., Bebbington, P., ... Garety, P. A. (2012). Jumping to conclusions, a lack of belief flexibility and delusional conviction in psychosis: A longitudinal investigation of the structure, frequency, and relatedness of reasoning biases. *Journal of Abnormal Psychology, 121*, 129–139. https://doi.org/10.1037/a0025297.

Statham, V., Emerson, L. M., & Bowie, G. (2019). A systematic review of self-report measures of paranoia. *Psychological Assessment, 31*, 139–158. https://doi.org/10.1037/pas0000645.

Steingrüber, H. J. (2010). *Hand-Dominanz-Test: H-D-T* [Hand-Dominance-Test: H-D-T] (3rd ed.). Göttingen: Hogrefe.

Steelcote, G. S., & Chambless, D. L. (1992). Methodological issues in prediction of treatment outcome. *Clinical Psychology Review, 12*, 387–400. https://doi.org/10.1016/0272-7358(92)90123-P.

Sutin, A. R., Terracciano, A., Kitner-Triolo, M. H., Uda, M., Schlessinger, D., & Zonderman, A. B. (2012). Personality traits prospectively predict verbal fluency in a lifespan sample. *Psychology and Aging, 26*, 994–999. https://doi.org/10.1037/a0024276.

Thewissen, V., Bentall, R. P., Oorschot, M., à Campo, J., van Lierop, T., van Os, J., & Myin-Germeyns, I. (2011). Emotions, self-esteem, and paranoid episodes: An experience sampling study. *British Journal of Clinical Psychology, 50*, 178–195. https://doi.org/10.1348/014466510X509877.

Tiegreen, J. A., & Combs, D. R. (2017). An examination of sub-clinical paranoia in a correctional setting. *Journal of Experimental Psychopathology, 8*, 320–331. https://doi.org/10.5127/jepr.045014.

Tone, E. B., & Davis, J. S. (2012). Paranoid thinking, suspicion, and risk for aggression: A neurodevelopmental perspective. *Development and Psychopathology, 24*, 1031–1046. https://doi.org/10.1017/S0954579412000521.

Triebwasser, J., Chermerinski, E., Rousso, P., & Siever, L. J. (2013). Paranoid personality disorder. *Journal of Personality Disorders, 27*, 795–805. https://doi.org/10.1521/pedi_2012_26_055.

van der Velde, J., Opmeer, E. M., Liemburg, E. J., Bruggeeman, R., Nieboer, R., Wunderink, L., & Aleman, A. (2015). Lower prefrontal activation during emotion regulation in subjects at ultrahigh risk for psychosis: An fMRI study. *NPJ Schizophrenia, 1*, 1526. https://doi.org/10.1038/npjpschz.2015.26.

Velotti, P., Garafolo, C., Petrocchi, C., Cavallo, F., Popolo, R., & Dimaggio, G. (2016). Alexithymia, emotion dysregulation, impulsivity and aggression: A multiple mediation model. *Psychiatry Research, 237*, 296–303. https://doi.org/10.1016/j.psychres.2016.01.025.

Weber, H., Assunção, V. L., Martin, C., Westmeyer, H., & Geisler, F. C. (2014). Reappraisal inventiveness: The ability to generate different reappraisals of critical situations. *Cognition and Emotion, 28*, 345–360. https://doi.org/10.1080/02699931.2013.832152.

Wendt, P. E., & Risberg, J. (1994). Cortical activation during visual spatial processing: Relation between hemispheric asymmetry of blood flow and performance. *Brain and Cognition, 24*, 87–103. https://doi.org/10.1006/brcg.1994.1005.

Westermann, S., Boden, M. T., Gross, J. J., & Lincoln, T. M. (2013). Maladaptive cognitive emotion regulation prospectively predicts subclinical paranoia. *Cognitive Therapy and Research, 37*, 881–885. https://doi.org/10.1007/s10608-013-9523-6.

Westermann, S., Kesting, M. L., & Lincoln, T. M. (2012). Being deluded after being excluded? How emotion regulation deficits in paranoia-prone individuals affect state paranoia during experimentally induced social stress. *Behavior Therapy, 43*, 329–340. https://doi.org/10.1016/j.beth.2011.07.005.

Westermann, S., & Lincoln, T. M. (2011). Emotion regulation difficulties are relevant to persecutory ideation. *Psychology and Psychotherapy: Theory, Research and Practice, 84*, 273–287. https://doi.org/10.1111/j.1475-6803.2010.023019.x.

Westermann, S., Rief, W., & Lincoln, T. M. (2014). Emotion regulation in delusional-prone individuals: Deficits in cognitive reappraisal, but not in expressive suppression. *Psychology and Psychotherapy: Theory, Research and Practice, 87*, 1–14. https://doi.org/10.1111/papt.12000.

Yamauchi, T., Sudo, A., & Tanno, Y. (2009). Relationship between anger and paranoid thoughts in a nonclinical sample. *Psychological Reports, 105*, 375–380. https://doi.org/10.2466/pr0.105.3.375-380.

Zimmermann, J., Altenstein, D., Krieger, T., Grosse Holthforth, M., Pretsch, J., Alexopoulos, J., ... Leising, D. (2014). The structure and correlates of self-reported DSM-5 maladaptive personality traits: Findings from two German-speaking samples. *Journal of Personality Disorders, 28*, 518–540. https://doi.org/10.1521/pedi_2014_28_130.