

Enjoying others' distress and indifferent to threat? Changes in prefrontal-posterior coupling during social-emotional processing are linked to malevolent creativity

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ABSTRACT

Malevolent creativity is characterized by malicious interpersonal goals aimed at damaging others. Neuro-cognitive processing patterns of negative social-emotional signals may explain variance in this disruptive phenomenon. This study examined whether individuals' brain responses to emotional expressions of others are linked to their capacity of malevolent creativity in a psychometric test. State-dependent changes of prefrontal-posterior EEG coherence were recorded while $n = 60$ participants listened to other people's anger, desperate crying, and laughter. These EEG measures were used to indicate affective dispositions towards emotional absorption (decreased coherence) or detachment (increased coherence) from others' emotional states. Results showed that higher malevolent creativity was reflected in relatively greater increases of EEG coherence during others' expressions of anger, and conversely, relatively greater decreases of EEG coherence during others' desperate crying. This pattern suggests that the generation of creative ideas for malicious, antisocial purposes may be partly attributed to an indifference towards others' aggression and potential retaliation, and partly to finding others' adversity rewarding on a neuronal level, increasing the quantity of ideas and the chances of hurting others. This first study linking malevolent creativity to social-emotional brain functions may offer novel insights into affective dispositions that may help understand individuals' potential for creative destruction.

1. Introduction

Traditionally, creativity is understood to be a positive, highly constructive cognitive activity, either in terms of self-expression, positive emotions, and greater well-being (Acar et al., 2020; Chermahini & Hommel, 2012) or as an overarching engine of cultural and scientific progress (Fink & Benedek, 2019; Stein, 1953). Yet, among darker aspects of creativity, individuals are also known for using their creative potential towards antisocial and decidedly malicious goals. Malevolent creativity refers to creative ideation that is deliberately exercised in order to inflict physical, mental, or material harm on others (Cropley et al., 2008; Cropley, 2010). As a crucial feature of malevolent creativity, creative ideas are intentionally and explicitly geared towards damaging or exploiting others and are not an unintended byproduct of versatile creative ideation (James et al., 1999; Kapoor & Khan, 2016).

While malevolent creativity is best exemplified in unprecedented terrorism, novel warfare, or complex criminal pursuits (Gill et al., 2013; Logan et al., 2020), incidences of lying, manipulation, harassment, theft, revenge, or property destruction accentuate its harmful potential in everyday life (see e.g., Harris et al., 2013; Harris & Reiter-Palmon, 2015; Walczyk et al., 2008). In order to counteract the repercussions of this destructive phenomenon, it seems vital to gain a deeper understanding of individual characteristics that may fuel the generation of malicious, creative ideas.

Quite robust links have emerged for a variety of maladaptive personality traits like antagonism, aggressiveness, impulsivity, low conscientiousness, and dark triad traits like psychopathy and Machiavellianism, which seem to highlight antisocial, callous, and exploitative roots of malevolent creativity (Hao et al., 2016, 2020; Harris & Reiter-Palmon, 2015; Jonason et al., 2017; Lee & Dow, 2011; Perchtold-

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Stefan et al., 2020). While these studies propose that some individuals are more prone to malevolent creativity than others, there is also research stressing the importance of state aspects for the occurrence of malicious ideation. Individuals also demonstrated higher malevolent creativity when facing unfair circumstances, hostile work environments or being in an angry mood (Baas et al., 2019; Cheng et al., 2021; Harris & Reiter-Palmon, 2015; James et al., 1999; Malik et al., 2020), suggesting that anybody can be malevolently creative under soliciting circumstances. A comprehensive approach to malevolent creativity by Perchtold-Stefan et al. (2021b) showed that general creative potential, antagonistic personality, and individuals' state anger all explained unique variance in performance on a malevolent creativity task, proposing that cognitive factors, personality, and current negative affect may critically influence the expression of malevolent creativity in distinct ways.

The contribution of affective, social-emotional variables to malevolent creativity is particularly interesting, first, in light of the rich framework linking state affect and affect-related dispositions to general creative ideation (see e.g., Baas et al., 2008, 2016; Conner et al., 2018; Conner & Silvia, 2015; De Dreu et al., 2008; also see Perchtold-Stefan et al., in press), and second, because variations in emotional reactivity and functioning seem to predict aggressive and socially aversive behavior (Centifanti et al., 2013; Frick & Viding, 2009; Loney et al., 2003; Schimmenti et al., 2019). The latter research alludes that antagonistic personality traits, particularly on the callous-psychopathic spectrum, are linked to emotional deficiencies in terms of low affective empathy, low emotional contagion, and lower emotional reactivity to negative stimuli (Frick & Viding, 2009; Jonason & Krause, 2013; Lishner et al., 2015; Wai & Tiliopoulos, 2012). These findings indicate more blunted emotional processing and a lower impact of negative social-emotional information in individuals with respective profiles. Conversely, there are also studies that link aversive traits, mostly impulsive, antisocial ones, to heightened emotional reactivity, and more automatic processing of negative emotions (Loney et al., 2003; Verona et al., 2012). Moreover, Centifanti et al. (2013) found that individuals with a grandiose and narcissistic personality paid increased attention to negative emotional cues indicating other's distress and suffering, reflecting a greater impact of negative social-emotional information. Given that malevolent creativity is associated with the abovementioned socially aversive traits (see Jonason et al., 2017; Lee & Dow, 2011; Perchtold-Stefan et al., 2020), and in daily life, is more likely to be exerted in negative social situations (Baas et al., 2019; Harris & Reiter-Palmon, 2015), this leads to the intriguing research question whether individuals high in malevolent creativity are more or less susceptible to negative emotions of others.

The present study investigated whether individuals' automatic responses to the perception of other individuals' emotional states signaling aggression (anger), sadness (despair), and happiness would be related to their capacity for malevolent creativity in a newly developed maximum performance test (Malevolent Creativity Test, MCT; Perchtold-Stefan et al., 2021b). The MCT consists of four realistic social situations depicting different types of unfair or provocative behavior from interaction partners and instructs participants to generate as many original ideas as possible in order to take revenge on or sabotage the wrongdoer. Similar to traditional divergent thinking measures, the MCT scores different aspects of malevolent creativity ideation: total number of generated ideas (ideational fluency), degree of harmfulness (malevolence), and originality (uniqueness) of generated ideas, as well as a composite malevolent creativity score, which may present different associations to variables of interest (see Perchtold-Stefan et al. 2020, 2021a,b, 2022, in press).

Since immediate, subtle reactions to incoming affective information are rather difficult to capture by means of self-report or behavioral observation (Allen et al., 2012; Schwerdtfeger, 2004, also see Papousek et al., 2016), we focused on individuals' brain responses during the processing of social-emotional information. At the neurobiological level,

modulation of incoming affective information is believed to be reflected in phasic changes of functional coupling of the prefrontal and posterior association cortex. More generally, it was demonstrated that affective processing is not only modulated by prefrontal top-down control over subcortical areas like the amygdala (see Davidson, 2002; Johnstone et al., 2007), but also over posterior sensory and association cortices, which highlights the role of cortico-cortical circuits in dynamic affect perception and awareness (Decety & Moriguchi, 2007; Miskovic & Schmidt, 2010; Vuilleumier & Driver, 2007). Functional communication and connectivity between two neuronal populations are reflected in changes of EEG coherence between these two scalp areas (Fries, 2005; Srinivasan et al., 2007). Accordingly, changes in EEG coherence during the processing of social-emotional information have been increasingly utilized to quantify the impact of this perceptual input on the individual. Miskovic and Schmidt (2010) demonstrated that prefrontal-posterior EEG coherence increased during exposure to highly threatening pictures, which was equated to a regulatory mechanism shielding the individual from aversive input, i.e., dampening of the overall emotional experience. Further studies also revealed crucial interindividual differences in these brain responses to social-emotional information, showing that reduced prefrontal-posterior coupling, reflected in smaller EEG beta coherences and specific to the right hemisphere, was associated with greater impact of the affective input on the individual (Papousek et al., 2013ab; Papousek et al., 2014, 2016; Reiser et al., 2012, 2014). These findings established a framework in which looser prefrontal-posterior coupling (decreased EEG coherence) during social-emotional processing is indicative of lower prefrontal control over incoming perceptual information and an opening of the perceptual gate, allowing the brain to become more affected by the emotional input. By contrast, increased prefrontal-posterior coupling (increased EEG coherence) indicates greater detachment or shielding from social-emotional signals, i.e., closing the perceptual gate and being less affected (c.f. Papousek et al., 2016, 2017; also see Miskovic & Schmidt, 2010).

In the present study, EEG coherence changes were recorded while participants listened to emotional sound clips of two strong negative emotions – aggression (anger), and sadness (despair) – both of which are imminently relevant in the context of malevolent creativity. While only a few previous studies have discussed the role of emotions for malevolent ideation, there is some indication that individuals high in malevolent creativity may have a heightened proneness to perceive and experience anger. Hao et al. (2016, 2020) delineated a strong, positive relationship between malevolent creativity behavior in daily life and trait anger and aggression, suggesting that malevolent ideation may be used as a form of defense in response to negative cues from the environment. Further, Perchtold-Stefan et al. (2021a) observed that individuals with a high capacity to generate malevolent creative ideas (MCT) incorporated a higher degree of revenge ideation in their attempts to cognitively reappraise anger-eliciting situations, which may indicate less effective downregulation of negative affect, and thus, greater susceptibility to anger. If individuals are motivated to express malevolent creativity as a retaliatory reaction to perceived threats from the environment, it may be hypothesized that a high capacity for malevolent creativity is linked to a lower sensitivity threshold for aggressive cues. In our study, this should be reflected in decreased EEG coherence, and thus, a more open perceptual gate during emotional sound clips that signal anger.

For EEG coherence changes during listening to others' expressions of despair/sadness, we hypothesized the same effect as for anger, i.e., decreased EEG coherence and greater emotional absorption for individuals high in malevolent creativity, albeit for a different reason. Per definition, it is the desired goal of malevolent creative ideation to cause harmful consequences for others (Cropley et al., 2008), implying that individuals high in malevolent creativity may be particularly interested to see their targets hurting and desperate. Interestingly, Papousek et al. (2017) demonstrated that negative emotional expressions of others may indeed have a rewarding value for individuals that are driven by latent

interpersonal goals to ridicule and ostracize others, which was reflected in decreased EEG coherence during other peoples' crying. In light of similar malicious, antisocial goals, it is plausible that individuals high in malevolent creativity may show a similar brain response in the present study that reveals a greater willingness to process the despair of others.

However, there is another possible outcome for both emotional stimulations. Harm-based creativity has also been linked to dark triad traits like psychopathy and Machiavellianism (Jia et al., 2020; Jonason et al., 2017; Kapoor, 2015), which are themselves closely associated with a lack of empathy, reduced emotion perception, and emotional coldness (Jonason & Krause, 2013; Petrides et al., 2011; Wai & Tiliopoulos, 2012). If malevolent creativity represents a callous, instrumental means of aggression, it may be linked to a general indifference to others' feelings and thus, greater detachment from social-emotional signals. This could alternatively be reflected in increased EEG coherence, and a more closed perceptual gate during processing of others' emotions in general, irrespective of type and valence. To test this idea of general poor emotional responding in malevolent creativity (also see Harris et al., 2013), we also included EEG coherence changes in response to other peoples' happy laughter in our analyses. However, since only one study indirectly touched upon the role of positive affect for malevolent creativity behavior in daily life (Khorakian et al., 2020), we did not formulate a specific hypothesis here.

In this study, we follow the proposal that prefrontal-posterior EEG coherence changes during affective processing qualify as trait-like dispositions, as they predicted variables with temporal distance to the EEG recordings in previous studies (Papousek et al., 2013a, 2017; Reiser et al., 2014). These general affective processing tendencies may also explain interindividual differences in malevolent creativity. Yet, such postulations only hold if it can be shown that the obtained brain-based responses to social-emotional signals are linked to malevolent creativity relatively independent of current affective states. For this reason, in our analyses, we also considered state negative affect, current depressive symptoms (indicative of altered emotion processing), as well as contagion and pleasantness ratings during socio-emotional stimulation as potential influencing factors.

2. Methods

2.1. Participants

A total of $n = 60$ participants (30 women) completed the experiment with all required data (age range 19 to 31 years; $M = 23.20$, $SD = 2.94$). Sample size was defined based on feasibility considerations, which resulted in a target sample size of around 60 participants. This allowed to detect at least medium-sized effects ($f^2 = 0.15$ to 0.20 , $\alpha = 0.05$, $1-\beta = 0.80$, multiple regression approach with at least two predictors of interest (EEG coherence during sadness and aggression stimulation)). Regarding levels of education, most participants were high school graduates (47), followed by university degree (10), and compulsory school (3). Right-handedness was confirmed by a standardized hand skill test (Steingrüber, 2010). Participants were invited to a study on emotion processing and recruited online via social media, and offline via posters at several university campuses. Initially interested individuals were phoned to check for exclusion criteria (drug use, psychoactive medication, neurological/psychiatric history, previous experience with the paradigms) and to arrange an appointment. Out of 68 interested individuals, $n = 3$ were excluded from participation due to psychoactive medication, and $n = 3$ did not show at their appointment. Additionally, $n = 2$ individuals had to be excluded after testing due to an insufficient amount of artifact-free EEG data. The study was conducted in accordance with the Declaration of Helsinki; the protocol was approved by the local ethics committee. Written informed consent was obtained from all participants.

2.2. Social-emotional stimulation

Four sound recordings were used, lasting 90 s each: (1) cheerfulness (hearty laughter), (2) despair/sadness (bitter crying and sobbing), (3) anger/aggression (angry shouting), and (4) neutral (soft murmurs and trivial everyday sounds), serving as the reference condition. In all sound clips, the respective emotions are expressed without using language (i.e., without words or parts of words) by small mixed-gender groups of people. Several previous studies successfully demonstrated the validity of the stimulus material, including its ability to evoke the respective states in the listeners (Papousek et al., 2013a, 2014, 2016, 2017, 2018; Reiser et al., 2012, 2014). Since the displayed emotions are unambiguous and rather intense, healthy participants have no difficulties in identifying and differentiating the expressed affective states (Papousek et al., 2013a; Reiser et al., 2012). Emotional sounds and (visual) pictures seem to be largely comparable in their elicitation of behavioral, physiological, and neuronal reactions (review by Gerdes et al., 2014). Yet, it was previously argued that auditory affective stimulations keep participants engaged for a longer duration, which compared to a brief stimulation with pictures, may increase ecological validity as participants get to more fully immerse themselves in realistic socio-emotional settings (Papousek et al., 2009, 2013a, 2018). Further, auditory stimuli strongly reduce the influence of personal characteristics of stimuli actors (attractiveness, physical resemblance to self, family members, friends, etc.) that may influence emotional responding (Papousek et al., 2018), which may play a role for the emergence of malevolent creativity. All sound clips were matched for peak sound intensity and sound level range and were presented over headphones. The order of sound clips was fully randomized, and each emotional sound clip was preceded and followed by a neutral one. Participants received instructions to direct their full attention to the sound recordings and imagine that they were part of the happenings. Before each sound clip, this instruction was briefly repeated to ensure best possible immersion.

2.3. EEG recording and quantification

During the emotional sound clips, EEG recording took place in a quiet, acoustically shielded room. EEG was recorded by 19 active electrodes using a Brainvision actiCHamp Research Amplifier (Brain Products™; 500 Hz sampling rate; 10–20 system), referenced to the nose and re-referenced offline to a mathematically averaged ear reference (Hagemann, 2004). Impedances were kept below 30 kΩ for all electrodes. All data were filtered using a 50 Hz notch filter and visually inspected for ocular and muscle artifacts. Fast Fourier Analysis was applied to artifact-free EEG data using a Hanning window (epoch length 1 s, overlapping 50%). The mean number of artifact-free epochs were $M = 112.52$ ($SD = 34.91$) for cheerfulness, $M = 126.87$ ($SD = 31.20$) for anger/aggression, $M = 136.82$ ($SD = 29.50$) for despair/sadness, and $M = 135.03$ ($SD = 31.08$) for the average neutral (reference) conditions. Spectral coherence (Fisher's z-transformed) was obtained. Since connectivity changes during affective processing were primarily observed in the beta frequency range by previous studies (13–30 Hz; Aftanas et al., 1998; Hao et al., 2019; Miskovic & Schmidt, 2010; Papousek et al., 2013ab, 2014, 2016, 2017; Reiser et al., 2012, 2014), our study focused on coherences in the beta range as well.

In line with previous relevant research, coherence pairs were grouped into anatomically valid clusters reflecting the left and right prefrontal cortex and posterior association cortex regions (see Miskovic & Schmidt, 2010; Papousek et al., 2014, 2016, 2017; Reiser et al., 2012, 2014). Coherence scores of nine electrode pairs each were averaged to summarize interaction within the left and the right hemisphere, respectively (left: Fp1-T7, Fp1-P3, Fp1-P7, F3-T7, F3-P3, F3-P7, F7-T7, F7-P3, F7-P7; right: Fp2-T8, Fp2-P4, Fp2-P8, F4-T8, F4-P4, F4-P8, F8-T8, F8-P4, F8-P8).

In order to calculate residualized change scores, linear regressions were run using EEG beta coherence during the neutral (reference)

condition prior to the emotional stimuli to predict the coherence during listening to each of the emotional sound clips (cf. Papousek et al., 2013ab, 2014, 2016, 2017). The residualized scores reflect state-dependent relative decreases or increases of intra-hemispheric coherence in response to the social-emotional stimulation. We used this approach in order to ensure that the analyzed residual variability was due to the experimental manipulation, and not due to individual differences at baseline, as well as to control for measurement error occurring when repeated measures of the same kind are used (Linden et al., 1997; Steketee, 1992). The abbreviation “ Δ coh” designates change-of-coherences scores in subsequent analyses. Negative scores denote a relative decrease in prefrontal-posterior coherence; positive scores denote a relative increase in prefrontal-posterior coherence. For descriptive statistics, see Table 1.

The main analyses focused on prefrontal-posterior coherence changes in the right hemisphere, since previous studies suggested strong right-hemisphere dominance for coherence changes during social-emotional processing (cf. Papousek et al., 2013ab, 2014, 2016, 2017; Reiser et al., 2012).

2.4. Malevolent creativity test (MCT)

Participants' potential for malevolent creative ideation was measured with the psychometric Malevolent Creativity Test (MCT; Perchtold-Stefan et al., 2021b), which is based on the idea that individuals are more likely to show malevolent creativity when they are somehow provoked or treated unfairly by others (see Baas et al., 2019; Harris & Reiter-Palmon, 2015). Accordingly, in the MCT, participants face four negative social situations and generate as many original ideas as possible in order to take revenge on the depicted wrongdoers (e.g., *finding possible ways to get back at an inconsiderate roommate throwing a party during exam week*). Validity of the MCT was confirmed by previous studies showing significant links to verbal divergent thinking, antisocial and impulsive personality traits, and frequency of revenge fantasies during emotion regulation (Perchtold-Stefan et al., 2020; 2021a,b, 2022, in press). In the on-screen version of the MCT, each unfair situation is presented for 30 s together with a picture and participants are told to immerse themselves in the situation. Then, upon seeing a white question mark on screen, participants write down as many malevolently creative ideas as possible on a sheet of paper. Each ideation phase lasted for 3 min, until a short tone indicated a new situation appearing on screen. All item descriptions can be found in Perchtold-Stefan et al. (2021b).

Table 1
Descriptive statistics for all study variables.

	<i>M</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>	α
Malevolent creativity performance					
Total score	3.51	1.64	1	7	0.83
Fluency	4.97	1.62	2	8.75	0.85
Malevolence	2.24	0.32	1.50	3.28	0.80
Originality	2.18	0.32	1.55	3.07	0.69
State negative affect					
State negative affect	1.21	0.26	1	1.90	0.71
Depressive symptoms					
Depressive symptoms	9.42	5.75	0	31	0.75
EEG coherence changes					
Δ coh desperate crying	0.00	0.99	-1.82	3.12	
Δ coh aggression	0.00	0.99	-2.48	3.28	
Δ coh laughter	0.00	0.99	-1.48	3.66	
Emotional stimulation ratings					
Contagion desperate crying	51.60	27.41	0	100	
Contagion aggression	27.53	28.67	0	100	
Contagion laughter	72.41	25.89	0	100	
Pleasantness desperate crying	31.31	18.23	0	64.24	
Pleasantness aggression	12.05	20.72	0	91.78	
Pleasantness laughter	63.96	23.90	2.55	100	

Note. *M* = mean value; *SD* = standard deviation, *Min* = Minimum; *Max* = Maximum, α = Cronbach's alpha in this study (for MCT across all four items), *N* = 60, *N* = 58 for emotion stimulation ratings.

The MCT scoring protocol provides four different indicators of malevolent creativity performance: (1) ideational fluency as the total number of generated ideas that met the instructions of being (at least slightly) malevolent, (2) malevolence of ideas (other-rated harmfulness or maliciousness of ideas), (3) originality of ideas (other-rated uniqueness of ideas), and (4) total malevolent creativity as a composite score of all ideas that are at least moderately original. Ideational fluency was rated by two independent raters (ICC; two-way mixed, absolute = 0.91). Malevolence of ideas was scored on a 4-point Likert scale by five independent raters (3 female, 2 male), with a score of 1 indicating slight malevolence (e.g., *talking badly about the wrongdoer behind their back*) and a score of 4 indicating high malevolence (e.g., *holding the wrongdoer hostage and beating some sense into them*). Interrater reliability (ICC; two-way mixed, consistency) for malevolence was 0.94. The same four individuals rated originality of ideas, yet in separate data files and with a time-delay of about two weeks to minimize rating-bias from scoring malevolence. On a 4-point Likert scale, a score of 1 indicated low originality, a score of 4 indicated high originality. Interrater reliability was ICC = 0.92. A final, total score of malevolent creativity was computed by summing up the number of malevolent ideas with an average originality rating of ≥ 2 (= at least moderately original; for previous studies with this approach, see Perchtold-Stefan et al., 2020, 2021a,b). This approach reflects the notion that in order to meet the criterion for “true” malevolent creativity, ideas should be both, malevolent, and original (see Harris et al., 2013; Harris & Reiter-Palmon, 2015). See Table 1 for descriptive statistics of the MCT.

2.5. Self-report measures

2.5.1. Current negative affect

State negative affect upon arriving at the EEG lab was measured using the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988; German adaptation by Krohne et al., 1996). Participants reported to which extent they felt each of 20 emotions ‘at the moment’ using a 5-point scale ranging from 1 (‘very slightly or not at all’) to 5 (‘extremely’). The positive and negative subscales comprise ten adjectives each (e.g., enthusiastic, proud; afraid, upset). For the purpose of the present study and considering possible mood effects on malevolent creativity, only the state negative affect scale was used (Cheng et al., 2021; Perchtold-Stefan et al., 2021b).

2.5.2. Depressive symptoms

Depressive symptoms were assessed using the Center for Epidemiologic Studies Depression Scale (CES-D; German version: Hautzinger & Bailer, 1993), which is particularly suitable for measuring subclinical depressive experiences in the general population. Participants rate 20 items referring to mood and attributions over the past week.

2.5.3. Affect ratings during socio-emotional stimulation

Following each emotional sound clip, participants rated a) their level of emotional contagion (“I found the sadness/anger/cheerfulness of the group contagious”, from 0 “not at all”, to 100 “extremely”), and b) the level of pleasantness (from 0 “very unpleasant” to 100 “very pleasant”). All ratings were assessed 10 cm horizontal visual analog scales (scored in millimeters from 0 to 100) and completed with the computer mouse.

For descriptive statistics of all self-report measures, see Table 1.

2.6. Procedure

Upon arrival, participants completed the handedness test, rated their current affective state (PANAS; ~ 3 min), depressive symptoms (~3 min) and were seated in an acoustically and electrically shielded examination room, where the electrodes were attached (~30 min). Subsequently, the EEG was recorded during an initial two-minute resting condition with eyes closed. Next, participants listened to the emotional sound clips and rated their affective responses (~20 min). Participants

then worked on the Malevolent Creativity Test (MCT; ~ 15 min) and were later debriefed about the purpose of the experiment.

2.7. Statistical analysis

For preliminary data analysis, we tested whether participants' gender (independent sample t-tests) showed any significant associations with change-of-coherence scores (Δcoh), malevolent creativity, negative state affect, depressive symptoms, or affect ratings during the socio-emotional stimulation. Further, as part of a manipulation check, we tested whether participants' affect ratings (contagion, pleasantness) significantly differed across emotional sound clips (repeated-measures ANOVA). Please note that for affect ratings, the sample size of $n = 60$ is reduced to $n = 58$ due to missing data for two participants.

For the main research question, four multiple regression analyses were employed to examine the effects of brain responses to social-emotional signals (trait factors) on malevolent creativity. Δcoh during processing of others' laughter (cheerfulness), desperate crying, and anger expressions were simultaneously entered as predictors. By looking at zero-order correlations (r) and semi-partial correlations (sr), it can be examined whether potential links to malevolent creativity are mainly driven by Δcoh during specific emotions (i.e., anger or sadness), and whether malevolent creativity is related to unique variances in emotion-specific Δcoh independently from others (sr). While total malevolent creativity serves as the main dependent variable of interest, regression models were additionally run for MCT fluency, MCT malevolence, and MCT originality, in order to determine whether specific Δcoh explain unique variance in specific indicators of malevolent creativity.

Given that the relationships between Δcoh during specific emotions and malevolent creativity may be influenced by current affective states and self-reported feelings during the socio-emotional stimulation, we employed a second set of regression analyses that followed up on significant predictor effects in the main model. In these follow-up models, significant Δcoh predictors (e.g., Δcoh during desperate crying) were entered together with one affect variable (e.g., contagion rating during desperate crying), as well as their respective interaction ($\Delta\text{coh} \times$ contagion ratings) to see whether the previously obtained effects on malevolent creativity remained stable, even when controlling for additional affective factors. Follow-up analyses were run with negative state affect, depressive symptoms, as well as contagion and pleasantness ratings during socio-emotional stimulation. The statistical assumptions for the multiple regression models (i.e., linearity, ratio of cases to independent variables, normality, homoscedasticity, independence of errors, and absence of multicollinearity) were met.

Additionally, intercorrelations between the MCT subscales were computed. Results were considered statistically significant if $p < 0.05$ (two-tailed).

3. Results

3.1. Preliminary analyses

Independent sample t-tests revealed no significant differences in MCT scores (all p 's ≥ 0.113), EEG coherence changes (all p 's ≥ 0.681), negative state affect ($p = 0.581$), or self-reported depressive symptoms ($p = 0.173$) between women and men. However, gender differences were observed for affect ratings during listening to others' desperate crying: Women reported significantly higher contagion (women: $M = 60.30$, $SD = 23.88$, men: $M = 40.28$, $SD = 28.27$, $t_{56} = -2.63$, $p = 0.011$) and significantly lower pleasantness during the crying sound clip (women: $M = 26.37$, $SD = 19.48$; men: $M = 36.62$, $SD = 15.41$, $t_{56} = 2.21$, $p = 0.031$). There were no gender differences in affect ratings during listening to others' aggression or cheerful laughter (all p 's > 0.174).

Emotional contagion ratings differed significantly for listening to desperate crying, aggression, and cheerful laughter ($F_{2,56} = 33.05$, $p < 0.001$; $\eta^2 = 0.54$), with the highest contagion ratings reported for

laughter, followed by sadness, and anger. Pleasantness ratings also significantly differed between the three sound clips ($F_{2,56} = 72.64$, $p < 0.001$, $\eta^2 = 0.72$), with the highest pleasantness ratings again obtained for laughter, followed by sadness, and anger. See Table 1 for descriptive statistics.

3.2. Multiple regression models for malevolent creativity

3.2.1. Main model: Δcoh and malevolent creativity

Both Δcoh during listening to others' desperate crying and Δcoh during others' aggression explained unique portions of variance in total malevolent creativity. However, while greater decreases of coherence during others' desperate crying were associated with higher malevolent creativity ($sr = -0.37$, $p = 0.004$), greater increases of coherence during others' aggression were associated with higher malevolent creativity ($sr = 0.30$, $p = 0.015$). The contribution of coherence during others' laughter to malevolent creativity was not significant ($sr < 0.01$, $p = 0.970$). See Table 2 for details and Fig. 1 for an illustration of these results.

Follow-up analyses with MCT fluency showed a similar pattern as for total malevolent creativity. However, only greater decreases of coherence during perception of others' desperate crying were uniquely associated with higher ideational fluency on the MCT ($sr = -0.29$, $p = 0.026$), while there was only a marginal effect for coherence increases during other' aggression ($sr = 0.25$, $p = 0.054$, see Table 3). Analyses with MCT malevolence and MCT originality revealed no significant pattern of associations with coherence changes during social-emotional stimulation (all p 's ≥ 0.114 see Tables 4 and 5).

Follow-up regression models were computed for Δcoh during desperate crying and aggression and their associations with total malevolent creativity.

3.2.2. Follow-up models with affective covariates for Δcoh during crying

The unique effect of Δcoh during desperate crying on total malevolent creativity remained virtually unchanged, even when controlling for negative affect ($sr \Delta\text{coh} = -0.29$, $p = 0.028$), depressive symptoms ($sr \Delta\text{coh} = -0.26$, $p = 0.044$), contagion ratings ($sr \Delta\text{coh} = -0.29$, $p = 0.030$), or pleasantness ratings ($sr \Delta\text{coh} = -0.32$, $p = 0.017$) as well as their respective interactions with Δcoh . None of the affective variables nor the interaction terms showed any significant association with total malevolent creativity (all p 's > 0.270).

3.2.3. Follow-up models with affective covariates for Δcoh during aggression

Controlling for depressive symptoms ($sr \Delta\text{coh} = 0.23$, $p = 0.083$),

Table 2

Total malevolent creativity and changes in EEG coherence during emotional processing.

	Total malevolent creativity					95% CI LL	95% CI UL
	R^2	r	p	sr	p		
Δcoh desperate crying	0.18	-0.29	0.026	-0.37	0.004	-1.23	-0.25
Δcoh angry aggression		0.19	0.141	0.30	0.015	0.10	0.94
Δcoh cheerful laughter		-0.06	0.636	<0.01	0.970	-0.37	0.38

Note: Multiple regression analyses; Total malevolent creativity: $F(3,56) = 3.96$, $p = 0.012$; $R^2 =$ proportions of variance explained by the model in total, $r =$ Pearson correlation; $sr =$ semipartial correlation, CI = 95% confidence interval for unstandardized beta weights; LL = lower limit; UL = upper limit. Significant correlations are highlighted in bold font.

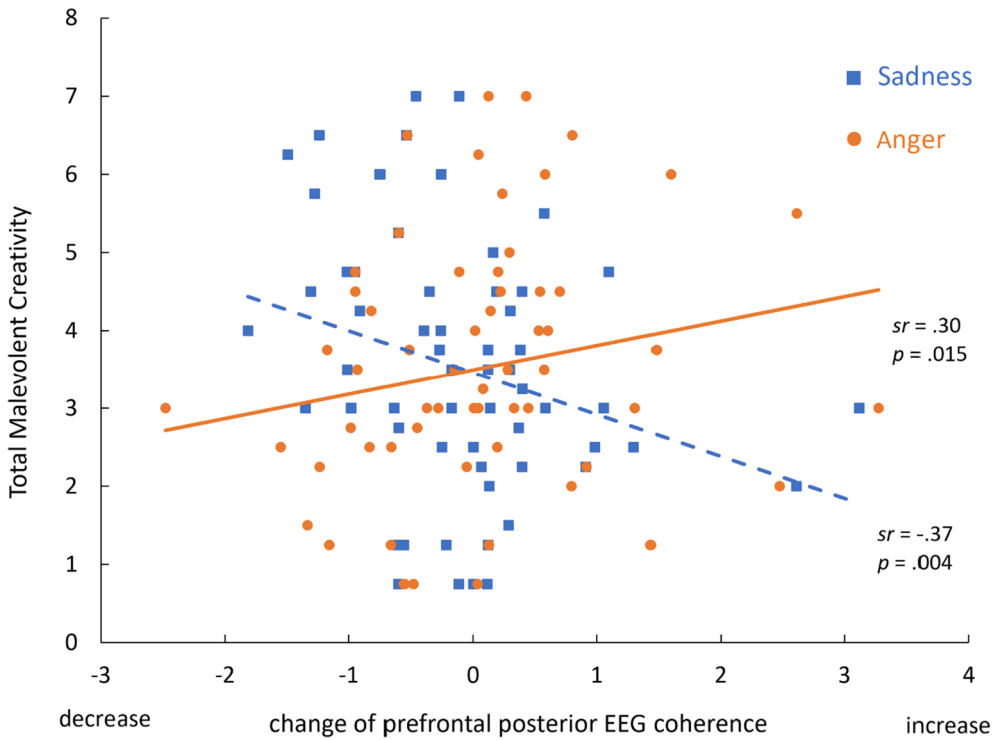


Fig. 1. Correlations between total malevolent creativity and changes of prefrontal posterior EEG coherence during listening to others' expression of anger (full line and dots) and desperate crying (dashed line and squares). Coherence changes in the right hemisphere in the beta frequency range relative to the neutral stimulation before (standardized residuals). Negative scores denote a decrease of prefrontal-posterior coupling, positive scores denote an increase of prefrontal posterior coupling.

Table 3
MCT fluency and changes in EEG coherence during emotional processing.

	Total Fluency							
	R^2	r	p	sr	p	95% CI	95% CI	
						LL	UL	
Δ coh desperate crying	0.11	-0.22	0.097	-0.29	0.026	-4.30	-0.28	
Δ coh angry aggression		0.16	0.217	0.25	0.054	-0.03	3.42	
Δ coh cheerful laughter		-0.01	0.950	0.05	0.731	-1.28	1.82	

Note: Multiple regression analyses; MCT fluency: $F(3,56) = 2.29, p = 0.089$; R^2 = proportions of variance explained by the model in total, r = Pearson correlation; sr = semipartial correlation, CI = 95% confidence interval for unstandardized beta weights; LL = lower limit; UL = upper limit. Significant correlations are highlighted in bold font.

contagion ratings ($sr \Delta$ coh = 0.24, $p = 0.072$), and pleasantness ratings ($sr \Delta$ coh = 0.22, $p = 0.098$) as well as their interactions with Δ coh reduced the previously significant association of Δ coh during aggression and malevolent creativity to trend-level. The addition of negative state affect to the regression model rendered the link between Δ coh and malevolent creativity no longer significant ($sr \Delta$ coh = 0.20, $p = 0.134$). Interestingly however, none of these affective variables nor the interaction terms showed a significant association with total malevolent creativity (all p 's > 0.160).

A summary of all models is reported in the [supplementary materials](#).

3.3. Intercorrelations between study variables

MCT fluency positively correlated with MCT originality at trend level ($r = 0.25, p = 0.054$), but was uncorrelated with MCT malevolence ($r = 0.04, p = 0.769$). MCT malevolence and MCT originality were positively correlated at $r = 0.35 (p = 0.006)$.

Table 4
MCT malevolence and changes in EEG coherence during emotional processing.

	MCT Malevolence							
	R^2	r	p	sr	p	95% CI	95% CI	
						LL	UL	
Δ coh desperate crying	0.05	-0.04	0.762	-0.05	0.729	-0.12	0.08	
Δ coh angry aggression		0.11	0.412	0.12	0.373	-0.05	0.13	
Δ coh cheerful laughter		-0.19	0.137	-0.18	0.165	-0.13	0.02	

Note: Multiple regression analyses; MCT fluency: $F(3,56) = 1.01, p = 0.394$; R^2 = proportions of variance explained by the model in total, r = Pearson correlation; sr = semipartial correlation, CI = 95% confidence interval for unstandardized beta weights; LL = lower limit; UL = upper limit. Significant correlations are highlighted in bold font.

Table 5
MCT originality and changes in EEG coherence during emotional processing.

	MCT Originality							
	R^2	r	p	sr	p	95% CI	95% CI	
						LL	UL	
Δ coh desperate crying	0.06	-0.01	0.963	-0.05	0.679	-0.12	0.08	
Δ coh angry aggression		0.20	0.123	0.21	0.115	-0.02	0.16	
Δ coh cheerful laughter		-0.13	0.366	-0.12	0.373	-0.11	0.04	

Note: Multiple regression analyses; MCT fluency: $F(3,56) = 1.19, p = 0.323$; R^2 = proportions of variance explained by the model in total, r = Pearson correlation; sr = semipartial correlation, CI = 95% confidence interval for unstandardized beta weights; LL = lower limit; UL = upper limit. Significant correlations are highlighted in bold font.

4. Discussion

In daily life, individuals' sensitivity to certain negative affective signals may play a pivotal role for their motivation to generate creative ideas for malicious, antisocial purposes. The present study investigated whether individuals' brain responses to incoming social-emotional information of others' aggression, desperate crying, and happiness were linked to their capacity for malevolent creativity. Our results confirmed the expected association between malevolent creativity and EEG coherence changes during stimulation with negative social signals. Yet, they also revealed a differential pattern for the processing of anger/aggression and sadness/despair that only partly matched our previous hypotheses. Individuals with a higher capacity for malevolent creative ideation showed greater relative increases of prefrontal-posterior coupling during listening to others' expressions of anger, indicating greater modulatory control over the input and dampening of the emotion experience, i.e., being less affected (Miskovic & Schmidt, 2010; Papousek et al., 2016; Reiser et al., 2012). Additionally, malevolent creativity was linked to greater relative decreases of prefrontal-posterior coupling during processing of others' desperate crying, which reflects an opening of the perceptual gate, allowing the brain to become more affected by this social-emotional signal (Papousek et al., 2013a, 2014, 2017; Reiser et al., 2014). No effects were observed for processing of other people's laughter/happiness.

In general, our results align with previous suggestions that correlates of individual differences in prefrontal-posterior coupling can be emotion-specific (Papousek et al., 2013a; Reiser et al., 2012). Interestingly, they simultaneously argue against the idea that malevolent creativity is associated with overall blunted emotional responding, as may have been hypothesized based on previous studies linking malevolent creativity to broader emotional deficits. Harris et al. (2013) reported a negative correlation between malevolent creativity and general emotional intelligence, while Sharma et al. (2015) noted low interpersonal awareness regarding emotions of others in convicted criminals, a population presumably higher in malevolent creativity. Similarly, malevolent creativity has been linked to dark triad traits that are usually characterized by an indifferent interpersonal core (Curtis & Jones, 2020; Jonason & Krause, 2013; Southard et al., 2015). In the present study, such greater general detachment from social-emotional signals would have likely reverberated in EEG coherence increases for all emotional stimulations. Instead, the neuronal responses of individuals high in malevolent creativity specifically suggested an indifference to social signals of anger and aggression. This is contrary to our assumption that malevolent creativity may be linked to a lower sensitivity threshold for aggressive environmental cues, which would have fit the idea that in daily life, malevolent ideation is often utilized as a means for revenge, and mostly represents a reactive type of antisocial behavior (see Hao et al., 2016; Perchtold-Stefan et al., 2021a). In this regard, Papousek et al. (2014) proposed that individuals high in positive schizotypy may be prone to inappropriate, hostile behavior in social situations due to impaired shielding from threatening information, which was evident in decreased EEG coherence during others' expressions of anger.

Interestingly, the antisocial and malicious aspects of malevolent creativity seem to be grounded in the opposite pattern of anger processing, namely highly effective shielding, and protection from others' aggression. A greater brain-based disposition to detach oneself from others' outrage and aggravation may increase individuals' willingness to violate societal norms and thus, generate malevolent creative ideas that are regarded taboo and socially unacceptable. While our follow-up analyses did not reveal a statistically significant pattern regarding what aspects of malevolent creativity may drive increased EEG coherence during others' anger, the pattern of associations was most prominent for MCT fluency and MCT originality, which are both combined in the total score of malevolent creativity. Thus, we speculate that individuals who are more detached from others' aggression may take greater risks when it comes to malevolently creative ideas to harm others, likely because

they are less concerned about retaliation or counter-aggression by the recipients of their revenge, which may boost both, frequency, and uniqueness of ideas.

Various aspects of risk-taking (particularly ethical risk) have been previously related to dark triad traits (Crysel et al., 2013; Hosker-Field et al., 2016), which in turn demonstrated links with greater harmfulness of creative ideas (Jonason et al., 2017). Notably, while research supports the idea of sensible risk taking in benevolent creativity (Sternberg, 1997; Tyagi et al., 2017), this is clearly not the case for malevolent creativity, where generated ideas often pass into criminal territory. In sum, it seems that the tendency to disregard aggressive, potentially threatening socio-emotional signals may be a decisive factor in the generation of truly dangerous ideas, which cannot be easily anticipated, and defended against (see Harris & Reiter-Palmon, 2015). However, while the idea of callous affect as a catalyst for antisocial and immoral behavior is well accepted (Jonason & Krause, 2013; Lishner et al., 2015; also see Paciello et al., 2020; Shirtcliff et al., 2009), existing models are not specific to anger perception. Further, while plenty of studies have examined anger in response to moral transgressions (e.g., Gutierrez & Giner-Sorolla, 2007; Russell & Giner-Sorolla, 2011), no previous investigation has focused on whether poor perception of other's anger specifically may facilitate moral violations and deviant behavior. Thus, our preliminary interpretation for malevolent creativity must be treated with caution.

Importantly, while EEG effects for others' desperate crying emerged independently from affective covariates and their interactions, coherence effects for angry aggression on malevolent creativity were less robust, particularly when controlling for state negative affect. While this does not negate our general interpretation on the role of anger processing for malevolent creativity, it also shows that this relationship may be further modulated by affective factors, and potentially, personality traits like the dark triad, hostility, or antagonism (see e.g., Papousek et al., 2018), which constitutes an important prospect for future studies.

We also obtained unique associations between malevolent creativity and individuals' brain responses to social signals of sadness/despair in the expected direction. A higher capacity for malevolent creative ideation was linked to greater relative decreases of EEG coherence, and thus, greater absorption of others' desperate crying. Since in malevolent creativity, creative ideas are purposefully generated in order to damage others (Cropley et al., 2008), it stands to reason that this outcome is also pleasurable to some degree. Research suggests that individuals with certain maladaptive personality traits regard others' adversity and suffering as a source of pleasure (Leach et al., 2003, 2015). This was not only demonstrated for dark triad traits, particularly psychopathy (James et al., 2014; Porter et al., 2014), but also for individuals high in moral disengagement (Erzi, 2020), desire for vengeance (Sawada & Hayama, 2012), and dark, malicious humor (Papousek et al., 2017). Our present findings indicate that positive reactions to others' misfortune may also motivate malevolent creativity, since individuals with a more open perceptual gate, i.e., decreased EEG coherence, during others' desperate crying scored higher on the MCT. The idea that decreased EEG coherence in response to certain social-emotional signals may signal a greater rewarding value for the individual was proposed by Papousek et al. (2017), who found that latent benevolent and malevolent goals of individuals matched their brain's susceptibility to others' laughter and crying. The authors reported that individuals preferring good-natured, benevolent humor seeking to cheer up others reduced their prefrontal-posterior coupling in response to other people's happy laughter, while individuals preferring malicious, dark humor aimed at ridiculing and dominating others reduced their prefrontal-posterior coupling in during other peoples' desperate crying (Papousek et al., 2017). The latter finding for malicious humor directly matches the present results for malevolent creativity. With the two being positively correlated in a previous study (Perchtold-Stefan et al., 2020), it may be suggested that individuals who find others' despair rewarding on a neuronal level may be more prone to a set of dark, antisocial behaviors that include the

generation of ideas towards harmful purposes. Notably, EEG coherence changes during others' crying seemed to be mostly driven by ideational fluency in the MCT. This specific correlation corroborates our idea that individuals who take pleasure in others' suffering would be motivated to generate a large pool of different malevolent ideas in order to maximize their chances of hurting others in various ways. This fits the idea of malevolent creativity in daily life, where a substantial portion of individuals engage in smaller-scale malicious behaviors such as lying, pranking, bullying, or exploiting others, which in their frequency may be just as damaging to victims as one highly malevolent action like physical assault (see Fullchange & Furlong, 2016 for a review on the deleterious effects of bullying).

Alternative to the rewarding value interpretation (Papousek et al., 2017), it has also been suggested that reductions of EEG coherence during certain emotional stimulations may signal emotional contagion and sympathizing (Reiser et al., 2012). According to this assumption, our results would indicate greater sympathizing and empathy with others' desperate crying in participants with a higher capacity for malevolent creativity. However, this would be completely opposed to established correlates of harm-based creativity in terms of antagonistic, callous, and exploitative personality traits (Jonason et al., 2017; Kapoor, 2015; Lebuda et al., 2021; Perchtold-Stefan et al., 2020, 2021a,b). It could be demonstrated that individuals high in psychopathy and callousness, while paying increased attention to the distress of others (Centifanti et al., 2013) and deliberately seeking out stimuli depicting others in pain (Porter et al., 2014), show lower emotional contagion of sadness and low empathic concern to those in need (Lee & Gibbons, 2017; Lishner et al., 2015). Instead, they report experiencing greater satisfaction at the suffering and misfortune of others (James et al., 2014), which is in line with opening their perceptual gate to others' desperate crying.

The present study is the first to demonstrate that malevolent creativity may be rooted in relevant social-emotional brain functions that indicative sensitivity to negative affective signals of others. As a first step in the investigation of emotional processing and malevolent creativity, our primary goal was to determine whether the well-validated stimulation with socio-emotional sound clips and the associated brain responses would explain variance in antisocial creative ideation. Individuals high in malevolent creativity showed increased EEG coherence and thus, greater emotional detachment during sound clips signaling angry aggression, possibly indicating that they are unperturbed by the potential consequences of their malevolent actions. Conversely, individuals who were skilled in generating a large pool of malevolent creative ideas in order to sabotage or take revenge on others displayed decreased EEG coherence during others' desperate crying, indicating that they may take pleasure in others' adversity. While we consider the use of EEG coherence changes as a well-established physiological measure of affective processing a strength of the present study (Miskovic & Schmidt, 2010; Papousek et al., 2014; 2016; 2017; Reiser et al., 2012; 2014), some limitations must be noted. Despite controlling for affective states and contagion/pleasantness ratings, we did not additionally control for antisocial personality traits, which may further modulate the association between brain responses to aggression and malevolent creativity (see Papousek et al., 2018). It is plausible that the link between indifference to others' aggression and malevolent creativity is even stronger in individuals scoring high on antagonism and detachment (personality dimensions with an indifferent interpersonal core; Southard et al., 2015), and conversely, weaker in those with low scores. Accordingly, future studies could strengthen the present results by using additional personality covariates, as well as other psychophysiological measures indicative of emotional perception (e.g., heart rate responses; Papousek et al., 2013b). It may also be warranted to examine individuals' responses to emotional sound clips capturing fear/anxiety, which may potentially reveal a similar reward-signaling pattern as observed for others' despair/sadness in those high in malevolent creative ideation. Importantly, since the present study linked individuals'

brain responses to social-emotional signals to their theoretical capacity for malevolent creativity in provocative social settings, it cannot be inferred that the findings also translate to real-life malevolent creative actions. While MCT performance proved to be positively correlated with self-reported malevolent creativity behavior in daily life (Perchtold-Stefan et al., 2021b), future investigations should replicate and extend the observed relationships in samples with a clear record of malevolent (creative) behavior (e.g., records of bullying, or criminal convictions). Finally, as another critical step, EEG coherence changes during others' emotional expressions should be linked to EEG coherence changes while individuals engage in malevolent creativity, in order to validate and more comprehensively explore the nature of their associations. Given adaptations to the MCT paradigm, decreased EEG coherence while participants reflect on the impact of their malevolent ideas may mirror decreased coherence during listening to others' crying and thus, provide further evidence that individuals high in malevolent creativity consider the despair of others rewarding/pleasurable.

With research on affective correlates on malevolent creativity still sparse, the present study offers first insights into social-emotional brain functions that may partly explain individuals' potential for malevolent creative ideation. In terms of importance, clarity on affect-related dispositions that pertain to negative socio-emotional signals may help to understand and counteract the antecedents of malevolent creativity occurring in more ordinary, conflict-related social settings (e.g., workplace altercations, James et al., 1999; relationship disputes, or ingroup-outgroup situations, also on social media, see Saint Laurent et al., 2020).

CRediT authorship contribution statement

Corinna M. Perchtold-Stefan: Formal analysis, Methodology, Resources, Supervision, Writing – original draft, Writing – review & editing. **Andreas Fink:** Resources, Supervision, Writing – review & editing. **Christian Rominger:** Formal analysis, Methodology, Writing – review & editing. **Enikő Szabó:** Validation, Visualization, Writing – review & editing. **Ilona Papousek:** Conceptualization, Methodology, Project administration, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability statement

The research data supporting this publication is available from the corresponding author upon reasonable request.

Appendix A. Supplementary data

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