



Feelings of helplessness increase ERN amplitudes in healthy individuals

D.M. Pfabigan^{a,*}, N.M. Pintzinger^b, D.R. Siedek^a, C. Lamm^a, B. Derntl^{b,c}, U. Sailer^{a,d}

^a Social, Cognitive and Affective Neuroscience Unit, Faculty of Psychology, University of Vienna, Liebiggasse 5, A-1010 Vienna, Austria

^b Department of Health, Development and Psychological Intervention, Faculty of Psychology, University of Vienna, Liebiggasse 5, A-1010 Vienna, Austria

^c Department of Psychiatry, Psychotherapy and Psychosomatics, RWTH Aachen University, Pauwelstraße 30, D-52074 Aachen, Germany

^d Department of Psychology, Faculty of Social Sciences, University of Gothenburg, Haraldsgatan 1, SE-40530 Gothenburg, Sweden

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ABSTRACT

Experiencing feelings of helplessness has repeatedly been reported to contribute to depressive symptoms and negative affect. In turn, depression and negative affective states are associated, among others, with impairments in performance monitoring. Thus, the question arises whether performance monitoring is also affected by feelings of helplessness.

To this end, after the induction of feelings of helplessness via an unsolvable reasoning task, 37 participants (20 females) performed a modified version of a Flanker task. Based on a previously validated questionnaire, 17 participants were classified as helpless and 20 as not-helpless. Behavioral measures revealed no differences between helpless and not-helpless individuals. However, we observed enhanced Error-Related Negativity (ERN) amplitude differences between erroneous and correct responses in the helpless compared to the not-helpless group. Furthermore, correlational analysis revealed that higher scores of helplessness were associated with increased ERN difference scores. No influence of feelings of helplessness on later stages of performance monitoring was observed as indicated by Error-Positivity (Pe) amplitude.

The present study is the first to demonstrate that feelings of helplessness modulate the neuronal correlates of performance monitoring. Thus, even a short-lasting subjective state manipulation can lead to ERN amplitude variation, probably via modulation of mesencephalic dopamine activity.

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1. Introduction

Monitoring one's own actions, and in particular the detection of errors or unfavorable outcomes, is of outstanding importance for human beings. However, our perception of performance is not only influenced by objective external performance indicators, but also by internal affective states. Positively valenced internal states are considered to improve cognitive functions in general (Ashby, Valentin, & Turken, 2002; Isen, 2001; Isen, Daubman, & Nowicki, 1987). In contrast, the effect of negatively valenced internal states on cognitive performance is less well understood and difficult to predict (Ashby, Isen, & Turken, 1999; Mitchell & Phillips, 2007). Consequently, the question arises whether performance monitoring is affected by changes in internal states. Event-related potentials (ERPs) pose a useful investigation tool to address this question since they permit precision in the millisecond range.

Thus, they allow uncovering the time course of cognitive and emotional processes associated with performance monitoring.

Two ERPs, the Error-Related Negativity – ERN or Ne – (Falkenstein, Hohnsbein, Hoormann, & Blanke, 1991; Gehring, Goss, Coles, Meyer, & Donchin, 1993) and the Error Positivity – Pe – (Falkenstein, et al., 1991; Falkenstein, Hoormann, Christ, & Hohnsbein, 2000) are most relevant in the context of internal performance monitoring. The ERN is a response-locked negative ERP deflection over fronto-central electrode sites, peaking between 50–100 ms after the commission of an erroneous response. The anterior medial cingulate cortex [aMCC; the anterior supracallosal subdivision of cingulate cortex formerly labeled as anterior cingulate cortex (Vogt, 2005)] is thought to be the neuronal generator of the ERN as found by source localization studies (Dehaene, Posner, & Tucker, 1994; Hoffmann & Falkenstein, 2010) as well as functional neuroimaging data (Debener et al., 2005; Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004). This ERP component is hypothesized to index either response conflict (Botvinick, Carter, Braver, Barch, & Cohen, 2001) or a reinforcement learning signal of the basal ganglia indicating that events are worse than expected (Holroyd & Coles, 2002). A different theoretical account poses that the ERN and related ERPs such as the Feedback-Related Negativity (FRN; Miltner, Braun, & Coles, 1997) are sensitive to the subjective value of committed errors (Gehring & Willoughby, 2002;

* Corresponding author. Tel.: +43 1 4277 47132; fax: +43 1 4277 47193.

E-mail addresses: daniela.pfabigan@univie.ac.at (D.M. Pfabigan), nina.pintzinger@univie.ac.at (N.M. Pintzinger), d.siedek@aon.at (D.R. Siedek), claus.lamm@univie.ac.at (C. Lamm), birgit.derntl@univie.ac.at (B. Derntl), uta.sailer@psy.gu.se (U. Sailer).

Pfabigan, Alexopoulos, Bauer, Lamm, & Sailer, 2011; Yeung, Holroyd, & Cohen, 2005). The ERN precedes the Pe, a positive ERP deflection over fronto-central electrode sites, peaking between 200 and 500 ms after conscious error commission (Falkenstein, et al., 1991, 2000). Thus, the Pe is assumed to reflect conscious error processing (Larson, Perlstein, Stigge-Kaufman, Kelly, & Dotson, 2006; Nieuwenhuis, Richard Ridderinkhof, Blom, Band, & Kok, 2001) or affective responses to conscious errors (Falkenstein, et al., 2000; Overbeek, Nieuwenhuis, & Ridderinkhof, 2005). The ERN has been frequently investigated in the context of psychopathology and performance monitoring. However, for instance depressed individuals have been reported to display both larger (Chiu & Deldin, 2007; Holmes & Pizzagalli, 2008) and smaller (Olvet, Klein, & Hajcak, 2010; Schrijvers, De Bruijn, Destoop, Hulstijn, & Sabbe, 2010; Schrijvers, et al., 2009) ERN amplitudes than healthy controls. Olvet et al. (2010) tried to resolve this discrepancy by proposing that mild to moderate depressive symptoms might be related to ERN amplitude enhancement, whereas severe depressive symptoms might be related to ERN amplitude reduction.

Investigating the influence of long-lasting affective states or traits on neuronal correlates of performance monitoring, previous studies reported that individuals scoring high on anxiety and negative affect scales display enhanced ERN amplitudes (Hajcak, McDonald, & Simons, 2003a, 2004) and Pe decrement after error commission (Luu, Collins, & Tucker, 2000). Moreover, ERN enhancement was observed in individuals scoring high on negative affect and negative emotionality scales (Luu et al., 2000).

Interestingly, the influence of short-lasting affective states is less well understood. Previous studies revealed inconsistent and contradictory results. Two studies found ERN amplitude modulation in relation to positive affect induction. Enhanced ERN amplitudes were reported in a flanker task for trials with superimposed pleasant pictures compared to trials with unpleasant and neutral ones (Larson et al., 2006). In contrast, decreased ERN amplitudes were reported after the presentation of pleasant compared to neutral movie clips prior to a continuous performance task (Van Wouwe, Band, & Ridderinkhof, 2011). Wiswede, Münte, Goschke, and Rüsseler (2009) found enhanced ERN amplitudes during a flanker task when presenting unpleasant pictures prior to the flanker stimuli. Furthermore, enhanced ERN amplitudes were reported in participants receiving derogatory feedback during a flanker task (Wiswede, Münte, & Rüsseler, 2009), and after the induction of self-relevant failure in a probabilistic learning task (Unger, Kray, & Mecklinger, 2012). However, the induction of sad feelings via movie clips prior to a flanker task did not alter ERN amplitudes directly. Instead, the correlation between ERN amplitudes and self-reported sadness was moderated by neuroticism (Olvet & Hajcak, 2012). Moreover, a study by Clayson, Clawson, & Larson, 2011 failed to report ERN modulation after derogatory feedback in a flanker task. These contradictory results raise two issues. Firstly, it might be that the described discrepancies are related to different presentation modes of the affective stimuli. In this regard, Van Wouwe et al. (2011) proposed that pre-task affect induction might lead to a milder and more tonic effect than the repetitive presentation of affective stimuli. Secondly, it might be that affect induction influences neuronal correlates of performance monitoring more strongly in cases where participants were exceedingly engaged in task performance because they received individual and personalized feedback by the experimenter. Thus, the present study combined both assumptions and investigated a tonic affect induction procedure with concurrent high task involvement and subjective salience. In particular, participants performed a cognitive reasoning task with unsolvable items, thereby possibly inducing subjective feelings of helplessness. Subsequently, a simple choice reaction task was administered to investigate the consequences of the helplessness induction on behavioral and neuronal correlates of performance monitoring.

Feelings of helplessness can be considered as a specific variant of affect modulation. Seligman (1975) was the first to introduce the concept of learned helplessness. He postulated lack of control over aversive events as its main characteristic. Seligman (1975) concluded that uncontrollability induces motivational (e.g., decreasing escape behavior), cognitive (e.g., learning deficits; Mikulincer, 1994), and emotional deficits (feelings of anxiety and depression). Moreover, learned helplessness is considered to contribute to psychopathological conditions such as depression (Overmier, 2002). Seligman (1975) also drew parallels between learned helplessness and depression.

For the present study, we employed a learned helplessness induction explicitly targeting motivational and affective components of helplessness prior to a choice reaction task. Based on Wiswede, Münte, and Rüsseler (2009) who observed enhanced ERN amplitudes after the presentation of unpleasant pictures, we hypothesized that the induction of feelings of helplessness would yield comparable effects on error monitoring. Compared to previous studies merely presenting affective stimulus material, we chose an experimental manipulation addressing the perception of individual skills of our participants to directly manipulate subjective saliency.

We expected enhanced ERN amplitudes after error commission in helpless compared to not-helpless participants indicating depression- or negative affect-like stimulus processing in these individuals. In particular, we assumed that the amplitude difference between correct and erroneous responses (Δ ERN) would be enhanced in helpless participants. For the Pe amplitude, we expected larger amplitudes after error than correct responses (Falkenstein, et al., 1991). Additionally, we explored Pe amplitude variation of helpless and not-helpless participants and the potential effects of the helplessness induction on behavioral task measures such as reaction times, error rates, conflict adaptation, and post-error slowing. In particular conflict adaptation effects might be susceptible to the present helplessness manipulation. For instance, effects of mood induction on conflict-driven control have recently been observed (van Steenbergen, Band, & Hommel, 2010).

2. Material and Methods

2.1. Participants and measures

Initially, 50 volunteers (25 females) participated in our study. Thirteen participants had to be excluded from further analysis due to data acquisition artifacts ($n=2$), or due to committing less than five errors ($n=7$) or more than 200 errors ($n=4$). The remaining 37 participants (20 females) were aged between 19 and 34 years with a mean age of 25.27 ± 3.89 years. All participants were right-handed as assessed via the Edinburgh Handedness Inventory (Oldfield, 1971), had normal or corrected-to-normal vision, reported no past psychiatric disorder, and did not suffer from a current psychiatric disorder as assessed with a SCID-I screening (Wittchen, Wunderlich, Gruschwitz, & Zaudig, 1996). All participants gave written informed consent prior to the experiment. The study was conducted in accordance with the Declaration of Helsinki (1981) and local guidelines of the University of Vienna. Each participant received a remuneration of 20 Euros at the end of the experiment.

The experiment consisted of a helplessness induction phase in which a cognitive reasoning task was administered, and the experimental phase in which a reaction time task was administered. The helplessness induction phase was a prerequisite to manipulate participants' actual motivational and affective states. Prior and after the helplessness induction phase, participants were administered the German version of the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) to assess whether the helplessness induction led to individual changes in positive and negative affect. Moreover, participants filled in a modified version of a previously validated helplessness questionnaire directly after the helplessness induction phase (Bauer, Pripfl, Lamm, Prainsack, & Taylor, 2003; Fretska, Bauer, Leodolter, & Leodolter, 1999) asking for participants' general motivation, their experience of control when confronted with solvable reasoning tasks, and their experience of loss of control when confronted with unsolvable reasoning tasks. Ratings on eleven questions had to be given on a five-point scale

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