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Performance monitoring in obsessive–compulsive undergraduates: Effects of task difficulty

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ABSTRACT

Both obsessive–compulsive disorder and subclinical obsessive–compulsive (OC) symptoms seem to be associated with hyperactive error-related brain activity. The current study examined performance monitoring in subjects with subclinical OC symptoms using a new task with different levels of difficulty. Nineteen subjects with high and 18 subjects with low OC characteristics performed a random dot cinematogram (RDC) task with three levels of difficulty. The high and low OC groups did not differ in error-related negativity (ERN), correct-related negativity (CRN) and performance irrespective of task difficulty. The amplitude of the ERN decreased with increasing difficulty whereas the magnitude of CRN did not vary. ERN and CRN approached in size and topography with increasing difficulty, which suggests that errors and correct responses are processed more similarly. These results add to a growing number of studies that fail to replicate hyperactive performance monitoring in individuals with OC symptoms in task with higher difficulty or requiring learning. Together with these findings our results suggest that the relationship between OC symptoms and performance monitoring may be sensitive to type of task and task characteristics and cannot be observed in a RDC that differs from typically used tasks in difficulty and the amount of response-conflict.

1. Introduction

To rapidly detect errors is crucial for adaptive behavior in a changing world. Shortly after the commission of an error the error-related negativity (ERN, Gehring, Goss, Coles, Meyer, & Donchin, 1993; Gonner, Leonhart, & Ecker, 2008) or error negativity (Ne, Falkenstein, Hohnsbein, Hoormann, & Blanke, 1991) can be seen as a sharp negative deflection over medial fronto-central electrodes in the event-related potential (ERP). The anterior cingulate cortex (ACC) has been suggested as neuronal generator of the ERN using both functional neuroimaging and source localization studies (Debener et al., 2005; Dehaene, Posner, & Tucker, 1994; Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004; Van Veen & Carter, 2002). Several theories about the function of this component have been suggested such that it indicates mismatch detection (Falkenstein et al., 1991; Gehring et al., 1993), the amount of response conflict (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Yeung, Botvinick, & Cohen, 2004), or a reinforcement learning signal (Holroyd & Coles, 2002). Overall, different theories assume that the ERN serves as a signal to adjust cognitive control to improve subsequent performance (Ullsperger, Fischer, Nigbur, & Endrass, 2014). In addition to the ERN a smaller negative deflection with a similar timing and scalp distribution has been observed following correct responses (CRN, Ford, 1999). It is still debated whether both response-related negativities reflect the activity of the same process (Hoffmann & Falkenstein, 2010; Vidal, Hasbroucq, Grapperon, & Bonnet, 2000), different processes (Yordanova, Falkenstein, Hohnsbein, & Kolev, 2004) or whether both share one common process and the ERN reflects an additional error-specific process (Endrass, Klawohn, Gruetzmann, Ischebeck, & Kathmann, 2012; Luu & Tucker, 2001).

Beside this cognitive function there is growing evidence that motivational and emotional variables influence the ERN (Weinberg, Riesel, & Hajcak, 2012). Accordingly, increased ERN amplitudes have been associated with individual differences in personality or psychopathology that were linked to affective distress or anxiety (Olvet & Hajcak, 2008; Weinberg et al., 2012). A recent meta-analysis by Moser, Moran, Schroder, Donnellan, and Yeung (2013) supports the idea that worry or anxious apprehension is the underlying dimension of anxiety that is most closely related to error-monitoring. One of the most replicated findings linking the ERN to psychopathology is the enhanced ERN in OCD

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(Endrass & Ullsperger, 2014). Obsessive–compulsive symptoms are characterized by intrusive thoughts (obsessions, e.g. "There may be dangerous germs on my hand") and ritualistic behaviors (compulsions, e.g. several cycles of hand washing) to counteract potential consequences. These symptoms may be caused by hyperactive error signals that cannot be reduced through compensatory behavior (Pitman, 1987). To fulfill diagnostic criteria for OCD these symptoms have to be time consuming and accompanied by significant functional impairments (APA., 2013). In accordance with a dimensional approach to psychopathology enhanced ERN amplitudes have been observed in both patients with OCD (Endrass, Klawohn, Schuster, & Kathmann, 2008; Endrass, Riesel, Kathmann, & Buhlmann, 2014; Endrass & Ullsperger, 2014; Endrass et al., 2010; Gehring, Himle, & Nisenson, 2000; Hajcak, Franklin, Foa, & Simons, 2008; Johannes et al., 2001; Klawohn, Riesel, Grutzmann, Kathmann, & Endrass, 2014; Mathews, Perez, Delucchi, & Mathalon, 2012; Riesel, Endrass, Kaufmann, & Kathmann, 2011; Riesel, Kathmann, & Endrass, 2014; Stern et al., 2010; Xiao et al., 2011) and healthy individuals with obsessive–compulsive characteristics (Grundler, Cavanagh, Figueroa, Frank, & Allen, 2009; Hajcak & Simons, 2002; Kaczkurkin, 2013; Santesso, Segalowitz, & Schmidt, 2006). However, other studies have not observed the typical enhancement of ERN amplitudes with obsessive–compulsive symptoms (Grundler et al., 2009; Hammer, Kordon, Heldmann, Zurowski, & Munte, 2009; Kaczkurkin, 2013; Mathews et al., 2012; Nieuwenhuis, Nielen, Mol, Hajcak, & Veltman, 2005; O'Toole, Weinborn, & Fox, 2012). Interestingly, Grundler et al. (2009) reported evidence for enhanced ERN using a Flanker task in subjects with high scores in the Obsessive–Compulsive Inventory-Revised (OCI-R, Foa et al., 2002) but failed to find this enhancement in the same subjects using a probabilistic learning task. This pattern of results has been replicated, but only when using an easy flanker task version (Kaczkurkin, 2013). Consistent with that Nieuwenhuis et al. (2005) did also not find evidence for enhanced ERN amplitudes in OCD patients using a probabilistic learning task. Whereas Grundler et al. (2009) suggested that differences in error type (i.e., suboptimal choice vs. erroneous motor response) explain task effects, Nieuwenhuis et al. (2005) focused on differences in the determination of the stimulus–response mapping in explaining their null-result. However, these explanations cannot by applied to null-results reported in studies that did not use probabilistic learning tasks (Kaczkurkin, 2013; Mathews et al., 2012; O'Toole et al., 2012) and it has been suggested that response-conflict is necessary to observe enhanced ERN amplitudes associated with OC symptoms. These findings indicate that group differences might not be obtained in tasks that are very difficult (Kaczkurkin, 2013), do not include response conflict, have a undetermined stimulus–response mapping or require learning (Endrass & Ullsperger, 2014). Together with results indicating that the ERN varies significantly across tasks (Hoffmann & Falkenstein, 2010; Riesel, Weinberg, Endrass, Meyer, & Hajcak, 2013; Segalowitz et al., 2010) this emphasizes the impact of varying task characteristics on electrophysiological markers of performance monitoring and highlights the need to examine a wide range of task and systematically explore the influence of task characteristics.

Thus, we examined performance monitoring in subjects high or low in obsessive–compulsive characteristics using a random dot cinematogram (RDC) task, since it allows fine-grained and individual adjustments of task difficulty. In line with previous findings (Endrass et al., 2012; Falkenstein, 2004; Johannes et al., 2002; Pailing & Segalowitz, 2004a; Schreiber, Endrass, Weigand, & Kathmann, 2012) we expect to observe a decrease in ERN magnitude with increasing task difficulty. With increasing difficulty the stimulus response mapping should become more uncertain whereas errors in the easy condition were mostly incorrect motor responses. If the determination of the stimulus–response mapping or task difficulty account for inconsistent result regarding performance-monitoring in OCD, we expect an enhancement in ERN magnitude for high compared to the low OCI-R group only in the easy task condition.

2. Material and methods

2.1. Participants

173 undergraduate students (Humboldt-Universität zu Berlin) completed the Obsessive–Compulsive Inventory-Revised (OCI-R, Foa et al., 2002). The OCI-R is a self-report measure evaluating the distress due to obsessive–compulsive symptoms. It contains 18 items contributing to 6 subscales. Each item is rated on a 5-point Likert scale with regard to the distress caused by the described behavior. Accordingly, the OCI-R score ranges between 0 and 72. For the US version a cut-off score of 21 is suggested to be optimal to discriminate OCD patients from non-anxious individuals when considering both sensitivity and specificity (Foa et al., 2002)[1]. The OCI-R has retained excellent psychometric properties and can be used as a screening test as well as a measure of symptom severity. 23 subjects (10 female) from the top 25% and 20 subjects (11 female) from the bottom 25% of the OCI-R distribution formed the high and low OC groups, respectively. In addition to obsessive–compulsive symptoms sleepiness and personality traits were assessed using the Stanford Sleepiness Scale (SSS, Hoddes, Zarcone, & Dement, 1972) and the Neo Five Factor Inventory (NEO-FFI, Costa & McCrae, 1992). All subjects were screened for psychiatric disorders using the Structural Clinical Interview for DSM-IV (SCID-I, German version, Wittchen, Zaudig, & Fydrich, 1997). Three subjects from the high OC group were excluded from EEG recording because they fulfilled DSM-IV criteria for OCD. The remaining participants had normal or corrected-to-normal vision and reported no history of head trauma, neurological or psychiatric disease. Data of three subjects were excluded from analysis due to excessive EEG artifacts or small number of error trials (fewer then 6, Olvet & Hajcak, 2009). The final sample consisted of 19 high OC (9 female) and 18 low OC (8 female) subjects. Groups did not differ in their demographic characteristics, personality traits, and sleepiness, but group differences were observed for the OCI-R (see Table 1). All subjects received verbal and written information about the aims and procedures of the study and gave written informed consent. They received a payment or course credit for their participation.

2.2. Stimuli

A random dot cinematogram (RDC) was presented using Phyton for Windows XP in white against a black 19 inch computer monitor. The stimuli were similar to those used by Newsome and Pare (1988), Leon and Shadlen (1998). The viewing distance was 65 cm. 500 moving dots were presented in a circle with 7.45 deg in diameter at the center of the monitor. Dots were 2 pixels in diameter and moved with a speed of 7.45 deg/s. A percentage of dots moved coherently in a horizontal direction, either rightward or leftward. The remaining dots moved in randomly assigned direction.

2.3. Design and procedure

Fig. 1 presents the experimental design of the RDC task. Each trial started with the presentation of a central fixation cross

[1] For the German version a lower cut off was empirically identified and a score of 17 was suggested optimal (Gonner et al., 2008).