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Executive functions in borderline personality disorder

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ABSTRACT

Different domains of executive function such as working memory and response inhibition were investigated together with elementary cognitive processes in borderline personality disorder (BPD). Patients with BPD ($N=28$) were compared to nonpatient controls (NP, $N=28$) on eight tasks (e.g. n-back, Go/NoGo, CPT-AX). In order to separate impairments in different cognitive domains and to assess the influence of more elementary cognitive processes on executive functioning, tasks were embedded in a reaction-time-decomposition approach. BPD patients solved tasks with accuracies comparable to those of nonpatients. The only exception was the n-back task, for which working memory is required: here, error rates were higher and increased more prominently in BPD patients depending on working memory load. In most tasks, movement times were shorter for BPD patients than for nonpatients, while the quality of task-solving was comparable. The faster processing in the BPD group was observable starting with the simplest task, i.e. a simple reaction-time task. These findings suggest that domains of executive functioning are differentially affected in BPD. In contrast to load-dependent deficits in working memory, response inhibition processes were unimpaired. Faster action-related processes could be observed in BPD patients in a variety of tasks; however, these did not influence executive functioning.

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1. Introduction

In the last several years, a number of studies have aimed at characterizing neurocognitive alterations in borderline personality disorder (BPD). Although BPD is not regarded as a typically neurocognitive disorder, Judd (2005) proposed that neurocognitive impairments might constitute a key moderator in the development of BPD. The exact nature of such impairments is still under debate (see reviews: e.g., Dell'Osso et al., 2011; Fertuck et al., 2006). Some studies favour the view of a selective impairment in a single domain such as executive functioning, and emphasize deficits in response inhibition processes and working memory (e.g. Haaland et al., 2009). However, other studies report impairments in the majority of the applied testing procedures (e.g. Monarch et al., 2004). These suggest the existence of deficits in many cognitive processes, ranging from perceptual speed to memory, attention, and executive functions: that is, an unspecific generalised cognitive impairment. In a quantitative review of the

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literature, Ruocco (2005) summarised 10 studies on impairments of cognitive functions in BPD, categorising the different tests into six domains of cognitive functioning: attention, cognitive flexibility, speeded processing, learning and memory, planning, and visuospatial abilities. An impaired performance of the BPD group was evident in each of these domains. Ruocco linked these widespread neuropsychological deficits to the Jacksonian biopsychosocial model of BPD (Meares et al., 1999), which explains many BPD symptoms as resulting from disrupted connections between the prefrontal cortex and other regions of the brain.

While Ruocco's findings support the assumption of impairments in a variety of cognitive functions in BPD, meta-analyses are generally based on combinations of different tests that claim to measure the same functions; and Ruocco emphasized that the often-observed high heterogeneity of effect sizes within one domain of functioning might be linked to the diversity of tests that were combined in the analysis. Tests differ not only in their measurement procedures but also with respect to the specific facets of the target function they aim to measure. Thus, even if only a single facet is impaired, combining results of different tests can erroneously indicate a deficit in the whole domain, while actually only one subdomain is affected. Memory functions in BPD constitute such an example: while for the domain of memory processes, an effect size of 0.66 suggests a general memory

dysfunction, breaking down memory tests into verbal and non-verbal tasks clearly revealed a stronger alteration in nonverbal memory processes (see [Ruocco, 2005](#)).

The problem of intertwining different facets of a cognitive construct exists for single testing procedures as well as for meta-analyses. Most tests require not only the functionality of the cognitive process under investigation (e.g., working memory) but also a variety of other, more basal functions (e.g., perception- or action-related processes). If any one of these elementary processes is disturbed, it will affect performance in every task that is more complex, and mimic a deficit in the target function. Thus, the identification of a selectively impaired cognitive function requires the dissociation of the various cognitive processes involved in solving a specific task. However, most of the typically applied (neuro-)psychometric tests do not allow the estimation of the relative contribution of single cognitive functions to the total outcome. Therefore, they are not suited to identify a deficit of a single cognitive sub-function as cause for an impaired performance related to a specific disorder ([Krieger et al., 2001a](#)). This also holds true for the usage of test batteries that measure different cognitive functions by using different subtests. Generally, these subtests differ not only in regard to their target function but also with respect to difficulty, reliability, and the usage of cognitive processes that are not directly linked to the target function. The validity of direct comparisons of performance levels across subtests is thereby limited (see [Chapman and Chapman \(1978\)](#) and [Goldberg and Gold \(1995\)](#)). These problems in the analysis of cognitive dysfunctions have been discussed in the past by several authors regarding psychiatric disorders ([Goldberg and Gold, 1995](#); [Krieger et al., 2001a](#)) and somatic disorders ([Lis et al., 2008](#); [Verstraeten, 2007](#)).

One approach to handling this problem is the reaction-time-decomposition method, which was introduced into cognition research in the mid-nineteenth century ([Donders, 1868](#)). In this method, cognitive processes are analysed using sets of tasks that are equal with regard to the general experimental setting, but differ in that each task within a set involves one additional cognitive process. Each additional process is assumed to require time, and thus to lengthen the total processing time. Such an arrangement enables the estimation of the time demands of separate cognitive processes, simply by subtracting the reaction times between a given task and its control task. A deficit in a certain cognitive domain becomes evident in altered running times or error rates between groups, which can be observed in one task (the more complex main task) but not in the other (the simpler control task).

In the present study, we applied this approach to disentangle the contribution of different cognitive sub-processes to two types of established executive function tasks: the Go/NoGo task which draws on response inhibition, and the n-back task established in the investigation of working memory processes. Both domains of executive functions have attracted special attention in BPD research. Both are assumed to rely on the functionality of the prefrontal cortex, a brain region that is part of a fronto-limbic network believed to be dysfunctional in BPD. Several studies have indicated a hypo-activation of frontal regions that involve the dorsolateral prefrontal cortex, the orbitofrontal cortex, and the anterior cingulate cortex, accompanied by a hyper-reactivity of the amygdala. These alterations are assumed to constitute the cerebral correlates of dysfunction in BPD such as impaired emotion regulation and increased impulsivity ([Mak and Lam, 2013](#); [Mauchnik and Schmahl, 2010](#); [O'Neill and Frodl, 2012](#); [Ruocco et al., 2012](#)).

The aims of the present study were to investigate: (1) whether alterations in cognitive functioning in BPD are represented by a specific deficit within a single cognitive domain, such as executive

functioning, or as an unspecific impairment across all applied tasks, (2) whether different executive functions such as working memory and response inhibition are differentially affected in BPD, (3) whether the need to integrate different executive functions accentuates deficits, and (4) whether alterations in executive functions can be linked to impairments of more elementary cognitive processes, since some studies have suggested dysfunction of visual early processing and psychomotor speed in BPD. Based upon data that suggest widespread neurocognitive deficits in BPD, we hypothesized that an impaired performance in BPD subjects would be apparent across all tasks. Especially pronounced deficits were expected in working memory and response inhibition. We expected that the need to integrate these two domains of executive functioning would result in an accentuation of impairments. Since these functions rely on a network of brain regions involving prefrontal areas that have been linked to BPD psychopathology in the past, we expected that these deficits could not be explained exclusively by alterations in more basal cognitive processes, such as psychomotor speed.

2. Material and methods

2.1. Participants

A total of 56 subjects were enrolled in the study: 28 with BPD and a control group of 28 nonpatients (NP). The controls, who received a modest fee for participating in the study, were matched to the patient group for age, sex, and educational background. Mean age in the BPD group was 28.2 years (S.D.=8.5, range=18–48) compared to 27.7 years (S.D.=8.4) in the NP group. Both groups had 7 males and 21 females. Mean IQ scores, which were estimated by means of a multiple choice vocabulary test (MWT-B, [Lehrl, 1977](#)) were 98.1 (S.D.=11.1) in the BPD group compared to 100.1 (S.D.=13.0) in the NP group ($t=0.62$, $p=0.539$). Exclusion criteria for both groups included present or previous neurological disease, head trauma or epilepsy, current alcohol or drug dependence, acute and chronic psychotic disorders, bipolar disorders, and attention-deficit/hyperactivity disorder, as well as other medical conditions that may affect CNS functioning. Additionally, none of the nonpatients had an individual history (Mini-DIPS; [Margraf, 1994](#)) or family history of psychiatric disorders.

All BPD subjects were inpatients of the Psychiatric Department of the Justus-Liebig-University Hospital Giessen, Germany. The diagnosis of BPD was made according to DSM-IV criteria, and was determined by a senior psychiatrist and an experienced psychologist using a standardized clinical interview (SCID-II). With respect to other Axis II personality disorders, four patients also met the criteria for antisocial personality disorder, three for obsessive-compulsive personality disorder, four for avoidant personality disorder, and one for narcissistic personality disorder. Seventeen patients additionally met the criteria for a mood disorder (13 with mild current major depressive episode and four with moderate current major depressive episode), 10 for an anxiety disorder, and five for an eating disorder. Fifteen had a history of substance use disorder (SCID-I). All but five of the patients were on psychotropic medication, with 10 taking antidepressants, two taking neuroleptic medication, and 11 taking both. (See [Table 1](#) for further description of the sample characteristics.)

All participants gave their written informed consent prior to enrolling in the study. The study was approved by the local ethics committee of the University of Giessen, School of Medicine.

2.2. Cognitive tasks and measurement parameters

Elementary cognitive processes and executive functions were measured in eight tasks, presented in counterbalanced order. Following the rationale of the reaction-time-decomposition approach, each task was linked to a control task that involved comparable cognitive processes except for the target function. All tasks were comparable regarding the demands on perception and motor processes in that they used the same stimulus material and required comparable motor reactions. The task battery constituted a further development of the battery developed by [Krieger et al. \(2001a, 2001b\)](#); (see also [Lis et al. \(2008, 2011\)](#)).

In all tasks, two types of visual stimuli (30 triangles, 30 squares; stimulus presentation 50 ms) were presented in pseudo-random order on a computer screen. Subjects had to indicate their response by moving a cursor as fast as possible from a starting button to a corresponding target button, using pen movements on a graphic tablet. The starting and target buttons were displayed on the computer screen. Trials were self-paced, with subjects signalling the start of a trial by positioning the cursor at the starting button (see supplementary material

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