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Neuroimaging supports behavioral personality assessment: Overlapping activations during reflective and impulsive risk taking

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ABSTRACT

Personality assessment has been challenged by the fact that different assessment methods (implicit measures, behavioral measures and explicit rating scales) show little or no convergence in behavioral studies. In this neuroimaging study we address for the first time, whether different assessment methods rely on separate or overlapping neuronal systems. Fifty nine healthy adult participants completed two objective personality tests of risk propensity: the more implicit Balloon Analogue Risk Task (BART) and the more explicit Game of Dice Task (GDT). Significant differences in activation, as well as connectivity patterns between both tasks were observed. In both tasks, risky decisions yielded significantly stronger activations than safe decisions in the bilateral caudate, as well as the bilateral Insula. The finding of overlapping brain areas validates different assessment methods, despite their behavioral non-convergence. This suggests that neuroimaging can be an important tool of validation in the field of personality assessment.

1. Introduction

From the very beginning, research on human personality and attitudes has comprised different measurement sources including samples of behavior (e.g. Cattell, 1890). Today, self-report questionnaires represent the dominant approach. Nevertheless, there is renewed interest in alternative computerized modes of assessment. In particular objective personality tests (OPTs), which taps personality by analyzing actual behavior in computerized miniature situations (Ortner & Proyer, 2015; Ortner & Schmitt, 2014), as well as so called indirect assessment, for example through Implicit Association Tests (IAT; Greenwald, McGhee, & Schwartz, 1998) have gained prominence in recent years.

The validity of different measures of personality assessment is usually shown through their convergence (Eid & Diener, 2006). However, convergence of data gained through different methods is often not empirically confirmed. In past studies, OPTs did often not converge with indirect tests, and both OPTs and indirect tests showed very low or zero correlations with questionnaires in empirical research (Koch, Ortner, Eid, Caspers, & Schmitt, 2014; Dislich, Zinkernagel, Ortner, & Schmitt, 2010; Hofmann, Gawronski, Gschwendner, Le, & Schmitt,, 2005). Furthermore, data collected by different OPTs designed to measure the same construct often did not converge with each other (Dislich et al., 2010).

In order to explain the low convergence between indirect tests and questionnaires often referred to as "direct measures" (Hofmann et al., 2005), researchers have postulated two different processing modes based on dual-process theories of cognition (Smith & DeCoster, 2000; Strack & Deutsch, 2004): (i) implicit (=automatic, spontaneous) and (ii) explicit (=reflective, rational). Thus, implicit processing is considered to underlie more impulsive behavior, whereas explicit processing is considered to underlie more controlled behavior. Indirect tests as well as some OPTs have been suggested to assess more impulsive behavior relying on implicit processing whereas self-report questionnaires and a different subgroup of OPTs have been suggested to assess more reflective behavior relying on more explicit processing (Dislich et al., 2010). Thus, lacking or low convergence of different OPTs could be a result of their ability to assess different aspects of the same construct. Whereas one test may assess more explicit aspects of a construct, another one may assess more implicit aspects. These different processing modes may be represented in the activation of different brain networks. We therefore suggest that neuroimaging may shed new light on the non-convergence of data collected with different OPTs. In particular, one of the following patterns of results may underlie such differences: (i) there is no overlap between the neuronal systems involved in explicit and implicit processing. The two processing modes activate distinct brain networks (Alternative 1). (ii) The neuronal systems involved in implicit and explicit processing modes activate the same brain networks. However, con-

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trolled explicit processing activates additional areas, most likely areas involved in cognitive control, which would suggest that during explicit processing there is simply an adaption of the implicit behavioral tendency (Alternative 2).

To our knowledge, no neuroimaging study has compared the neuronal systems involved in implicit and explicit processing during assessment of personality traits. However, support for both alternatives comes from studies investigating dual-process models during learning, emotion processing, or social mentalizing. A study on implicit versus explicit learning supported the first alternative, indicating an involvement of the occipital cortex in recognition of implicitly learned content, while the hippocampus, prefrontal and midline areas were involved in recognition of explicitly learned content (Reber, Gitelman, Parrish, & Mesulam, 2003). Findings on implicit and explicit emotional processing, on the other hand, are in line with the second alternative (Cunningham, Raye, & Johnson, 2004; Van Overwalle & Vandekerckhove, 2013): During both, implicit and explicit emotion evaluation subcortical (Amygdala) and Insula activations were registered. In addition, explicit emotion evaluation involved activation of the anterior cingulate and lateral prefrontal cortices (Cunningham et al., 2004). Finally, data on implicit and explicit social mentalizing are also in line with the second alternative. Both types of social mentalizing activated the temporo-parietal junction (TPJ) and medial prefrontal cortex (mPFC). However, explicit social mentalizing yielded additional activation areas including the lateral prefrontal cortex (Van Overwalle & Vandekerckhove, 2013).

In the present study, for the first time functional imaging was used to assess differences and overlaps in brain activations between two behavioral measures of a personality trait. We chose risk propensity as an example trait, because it has been studied extensively both in the fields of personality assessment and by neuroimaging. Participants completed two OPTs assessing risk taking during fMRI: The Balloon Analogue Risk Task (BART; Lejuez, Read, Kahler, Richards, & Ramsey, 2004), which has been demonstrated to assess impulsive risk taking behavior (Reynolds, Ortengren, Richards, & de Wit, 2006), and the Game of Dice Task (GDT; Brand, Greco, Schuster, Kalbe, & Fujiwara, 2002), which has been demonstrated to assess reflective risk taking behavior (Dislich et al., 2010). The Balloon Analogue Risk Task requires pumping a balloon under an unknown probability of bursting – each pump leads to monetary gain, but also includes the risk of losing all gains in case of explosion. The Game of Dice Task represents a classical betting game. Participants have to decide between bets on two set of dice, one representing a higher possible loss, but also higher possible gain and one representing a lower possible loss, but also lower possible gain. For each bet, participants have explicit access to the probability of loss or gain. In a previous study (Dislich et al., 2010) winnings on the BART were in fact related to the implicit risk taking self-concept assessed via an IAT (medium effect size), but not to the explicit risk taking scores. Vice versa, winnings on the GDT were found to correlate with the explicit risk taking self-concept assessed via the Domain Specific Risk Taking Scale (DOSPERT; Johnson, Wilke, & Weber, 2004), a self-report risk-taking questionnaire, but not with the implicit risk taking scores. In the present study, the implicit and explicit nature of the BART and GDT were also cross-validated against an IAT, as well as an adaptation of the DOSPERT. We hypothesized that risky behavior assessed with the BART should yield different brain activation patterns as risky behavior assessed with the GDT. The aim of the present study was to decide, whether these systems are completely segregated (Alternative 1), or whether there is an overlap between the systems (Alternative 2).

For both the BART and the GDT previous fMRI studies are available (BART: Rao, Korczykowski, Pluta, Hoang, & Detre, 2008; Schonberg et al., 2012; Fukunaga, Brown, & Bogg, 2012; GDT: Labudda et al., 2010). Studies on both tasks report activations in the posterior parietal, lateral prefrontal (lPFC) and anterior cingulate cortices (ACC). For the BART involvement of the striatum and Insula has additionally been reported (Rao et al., 2008; Fukunaga et al., 2012). These results suggest at least a partial overlap between the neuronal systems involved in implicit and explicit risk taking. Such an overlap has however not been previously demonstrated in the same sample of participants. Furthermore, several factors challenge the comparison of these studies. First, in the GDT study, participants did not receive actual money as dice throws were purely hypothetical, while participants in the BART studies did receive money for participation, albeit it was a fixed amount in the study by Rao et al. (2008). Actual payment has however been demonstrated to be one important modulator of striatal activity in particular (e.g. Kang et al., 2011). Also, in assessment situations it is recommended that participants receive actual money for their winnings to enhance the ecological validity of the tasks.

Second the contrasts used to assess the neuroimaging correlates of risk taking differed between the two studies. While different regressors have been used in the BART studies, including participants choices (Fukunaga et al., 2012) or the parametric risk level irrespective of participants choice (Rao et al., 2008), for the GDT the condition where participants were informed about the incentives associated with each choice was contrasted to a condition were no incentives were presented, but choice behavior (risky vs. safe decision) was not taken into account. Third, in the BART activation of the ACC and lPFC was mainly associated with safe decisions as opposed to risky decisions (Fukunaga et al., 2012), while in the GDT activation of these areas was associated with the incentive vs. no incentive contrast.

In the present study, we adapted the two tasks with the following goals in mind:

First, we sought to model the same contrast in both tasks to allow for an adequate comparison and a conjunction analyses. Thus, the contrast risky vs. safe decisions was modelled for both tasks.

In order to ensure the involvement of the same neural processes as in the applied assessment situation, we second aimed for versions of the two tasks as similar as possible to the original version utilized in the context psychological assessment. This implied on the one hand, that participants received actual money for their winnings in both tasks. On the other hand, this implied that apart from the contrasts modelled, we sought to preserve the differences between the two task designs. Despite the implicit and explicit nature of the two tasks there were conceptual differences that might enhance their behavioral non-convergence. The aim of the present study was to investigate whether an overlap between the neuronal systems underlying both tasks could be found, despite these differences.

2. Materials & methods

2.1. Participants

Fifty nine healthy students (18 male, 41 female) with a mean age of 22.39 ± 5.14 years, who were all German native-speakers and without self-reported neurological, endocrinological or psychiatric disorders or observed brain tissue abnormalities on the structural MRI participated in the study. All students gave their informed written consent to participate in the study. All methods conform to the Code of Ethics of the World Medical Association (Declaration of Helsinki). The study was approved by the local Ethics committee.

2.2. Tasks

2.2.1. Neuroimaging tasks

All stimuli were presented on an MR-compatible back-projection screen using Presentation Software (version 0.71, 2009,