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# The burden of conscientiousness? Examining brain activation and cortisol response during social evaluative stress

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ABSTRACT

Although conscientiousness has for a long time been considered generally adaptive, there are findings challenging this view, suggesting that conscientiousness might be less advantageous during uncontrollable stress. We here examined the impact of conscientiousness on brain activation during and the cortisol response following an uncontrollable social evaluative stress task in order to test this hypothesis.

Brain activation and cortisol levels were measured during an fMRI stress task, where subjects (n = 86) performed cognitive tasks containing preprogrammed failure under time pressure, while being monitored by a panel of experts inducing social-evaluative threat. The degree of conscientiousness was measured using the NEO-FFI.

We observed a positive correlation between conscientiousness and salivary cortisol levels in response to the stressful task in male subjects only. In male subjects conscientiousness correlated positively with activation in right amygdala and left insula, and, moreover, mediated the influence of amygdala and insula activation on cortisol output. This pattern of brain activation can be interpreted as a disadvantageous response to uncontrollable stress to which highly conscientious individuals might be predisposed.

This is the first study showing the effect of conscientiousness on physiology and brain activation to an uncontrollable psychosocial stressor. Our results provide neurobiological evidence for the hypothesis that conscientiousness should not just be seen as beneficial, but rather as a trait associated with either costs or benefits depending on the extent to which one is in control of the situation.



## 1. Introduction

Conscientiousness (C) traditionally has been seen as a protective factor, providing longevity (Kern and Friedman, 2008) and subjective well-being (Steel et al., 2008), and moderating the relationship between daily hassles and health-behavior (O'Connor et al., 2009). However, others challenge the generally protective effect of conscientiousness, suggesting that conscientiousness is rather associated with either costs or benefits, depending on the situation (Nettle, 2006).

One indication that conscientiousness is not always advantageous for well-being is provided by a study showing that highly conscientious individuals experience a 120% higher decrease in life satisfaction than those at low levels when being 3 years unemployed (Boyce et al., 2010). In the context of unemployment, often perceived as severe and chronic failure, conscientiousness thus seems to be a trait that might in some circumstances constitute a risk for well-being (Boyce et al., 2010).

Additionally, it has been reported that highly conscientious individuals experience higher tension after receiving negative feedback

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than less conscientious individuals (Cianci et al., 2010). Similar to unemployment, negative feedback can be interpreted as failure that cannot easily be changed or controlled. It appears plausible that highly conscientious individuals become more strongly affected by experiences of failure, because of being high-achievers who are not self-indulgent (McCrae and John, 1992).

Beyond that conscientiousness is not only associated with achievement-striving but also with high levels of self-regulation, persistence, impulse-control, and self-discipline (McCrae and John, 1992). Highly conscientious individuals are thus likely to be motivated to succeed and to persist until a particular goal is attained. This might result in being rigidly attached to previously defined goals (Nettle, 2006), which in turn might induce increased stress levels in the context of uncontrollable failure. In other words, as conscientiousness seems to influence the importance of, and therefore the reaction to failure as well, which clearly represents a stressful experience for highly conscientious individuals because of their personal standards, expectations, and behavior, a rather detrimental effect of conscientiousness on well-being possibly depends on the processing of uncontrollable stressful experiences.

The influence of personality on the endocrine stress reaction has been investigated by several studies (Bibbey et al., 2013). The reported null findings concerning conscientiousness (Bibbey et al., 2013) could be due to the controllability of the stressor in these studies, as the effect of conscientiousness is suggested to be dependent upon the degree of control afforded during stress exposure (Bibbey et al., 2013).

In order to investigate the influence of conscientiousness on the neural and endocrine stress reaction, we investigated subjects with different levels of conscientiousness during an fMRI task inducing social evaluative threat and the experience of uncontrollable failure (Lederbogen et al., 2011), the combination of which is known to elicit the strongest stress reaction in a laboratory setting (Dickerson and Kemeny, 2004).

We tested the following parameters: behavior (subjective experience of stress), endocrine stress reaction (cortisol output, i.e. AUCg), and brain activity (fMRI). We hypothesized that highly conscientious participants will be more stressed in response to the task than their less conscientious counterparts reflected by increased levels of behavioral, endocrine, and neural responses to stress. At the neural level, we expected to find an association between conscientiousness and changes in brain activity in those brain areas that have been previously implicated in subjective perception and appraisal of stressful situations, i.e. amygdala, insula, and dACC (Kern et al., 2008; Tillfors et al., 2001; Wang et al., 2005). In addition, as gender differences in stress processing and cortisol response are well known (Duchesne and Pruessner, 2013), we also included sex as a variable of interest.

## 2. Material and methods

### 2.1. Participants

We recruited 86 (50 female, 36 male; mean age: 27 (±6.01 years)) healthy volunteers of European descent in Berlin. All participants were screened reporting no acute or chronic diseases, no recreational drug use, no medication and neither personal nor family history of DSM-IV axis I disorders during a structured clinical interview (Wittchen et al., 1997). All subjects met the safety requirements for participation in an fMRI study. The study was approved by the local ethics committee and written informed consent was given by all participants. We also assessed handedness, intelligence, Body Mass Index and psychometric variables, such as anxiety and depression scores, to exclude possible confounds. For demographic and behavioral measures see Table 1.

**Table 1**
Demographic and behavioral measures.

| | | N | mean | SD | *p* |
|---|---|---|---|---|---|
| Age | male | 36 | 27.03 | 5.45 | |
| | female | 50 | 28.18 | 6.40 | 0.384 |
| | all | 86 | 27.70 | 6.02 | |
| BMI | male | 36 | 23.46 | 2.66 | |
| | female | 50 | 22.62 | 3.23 | 0.204 |
| | all | 86 | 22.97 | 3.02 | |
| School certificate (Abitur, 10th grade) | male | 36 | 33/3 | | |
| | female | 50 | 47/3 | | 0.916 |
| | all | 86 | 80/6 | | |
| MWTB | male | 36 | 31.81 | 2.56 | |
| | female | 50 | 31.02 | 2.18 | 0.129 |
| | all | 86 | 31.35 | 2.37 | |
| STAI-T | male | 36 | 33.19 | 5.12 | |
| | female | 50 | 31.94 | 7.28 | 0.377 |
| | all | 86 | 32.47 | 6.46 | |
| BDI-II | male | 35 | 3.97 | 3.54 | |
| | female | 50 | 3.94 | 4.41 | 0.972 |
| | all | 85 | 3.95 | 4.05 | |
| conscientiousness | male | 36 | 32.03 | 6.95 | |
| | female | 50 | 34.98 | 5.60 | 0.032 |
| | all | 86 | 33.74 | 6.34 | |
| neuroticism | male | 36 | 13.61 | 5.59 | |
| | female | 50 | 14.22 | 6.41 | 0.648 |
| | all | 86 | 13.97 | 6.05 | |
| extraversion | male | 36 | 28.89 | 5.13 | |
| | female | 50 | 30.04 | 6.98 | 0.404 |
| | all | 86 | 29.56 | 6.27 | |
| openness | male | 36 | 32.92 | 6.31 | |
| | female | 50 | 32.76 | 5.73 | 0.918 |
| | all | 86 | 32.83 | 6.16 | |
| agreeableness | male | 36 | 31.81 | 6.49 | |
| | female | 50 | 35.24 | 5.04 | 0.007 |
| | all | 86 | 33.80 | 5.91 | |
| subjective stress | male | 36 | 1.78 | 0.90 | |
| | female | 49 | 2.14 | 0.71 | 0.039 |
| | all | 85 | 1.99 | 0.81 | |
| AUCi | male | 34 | 294.42 | 419.18 | |
| | female | 49 | 185.72 | 447.02 | 0.267 |
| | all | 83 | 230.25 | 436.55 | |
| AUCg | male | 34 | 1130.09 | 475.88 | |
| | female | 49 | 907.09 | 510.63 | 0.048 |
| | all | 83 | 998.44 | 505.91 | |
| Responder/Nonresponder | male | 34 | 27/7 | | |
| | female | 49 | 28/21 | | 0.058 |
| | all | 83 | 55/28 | | |
| Handedness (right/left/ambidextrous) | male | 36 | 34/2/0 | | |
| | female | 50 | 47/0/3 | | 0.085 |
| | all | 86 | 81/2/3 | | |

BMI, Body mass index, MWTB, Mehrfachwahl-Wortschatz-Intelligenztest, STAI-T, State-Trait-Anxiety-Inventory, BDI-II, Beck Depression Inventory, AUCi, Area under the curve with respect to increase, AUCg, Area under the curve with respect to ground. P-value refers to sex differences.

### 2.2. Stress task

To examine the influence of conscientiousness on brain activation and cortisol levels in response to uncontrollable stress the Scan*STRESS* paradigm was employed (Akdeniz et al., 2014; Lederbogen et al., 2011). Participants performed two runs (lasting 11:20 min per run), each consisting of four blocks of a stress condition and four blocks of a control condition. Every block lasted 60 s and was preceded by a 5 s screen indicating the specific task that had to be performed. Within each run, the order of blocks was as follows: Subjects first performed one block of mental spatial rota-