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Reward-related neural processing is modulated by approach- and avoidance-related personality traits

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Background

It has been suggested that the processing of reward can be differentiated into 2 sub-components with different functions, "wanting" (i.e. the expectation of a reward) and "liking" (i.e. the hedonic impact experienced during the receipt of a reward) (Berridge, 1996).

A biologically based personality model dealing with individual differences in appetitive functioning, i.e. the reinforcement sensitivity theory (Gray, 1970), postulates that the tendency to approach reward related situations (behavioural approach system, BAS) is mainly mediated via mesocortical circuits. It is however not clear how specifically the neural systems underlying wanting and liking relate to the behavioural activation vs. behavioural inhibition systems.

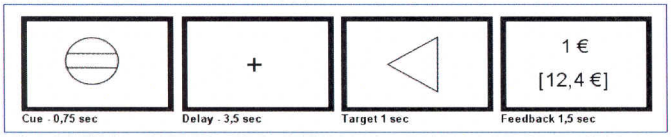
Therefore, the main goal of this study was to explore the relationship between reward-related neuronal processing and motivation-related personality traits in the normal, non-pathological range .

Methods

Subjects: 23 right-handed healthy university students (13 females, mean age 24.8 ± 3.2) participated in the study.

Scales: In order to assess motivational related personality traits, the Behavioural Inhibition/Behavioural Approach Activation Scales (BIS/BAS) (Strobel et al., 2001) as well as the achievement motive scale (AMS, Lang et al., 2006) were filled out by each subject.

Task: We employed a monetary incentive delay task (Knutson et al, 2001; Abler et al. 2005). Subjects were presented a cue indicating the possibility of winning either 1 Euro, 20 Cent or 0 Euro. After a delay period they had to perform a left or right button press within 1 s. After correct performance they would win the cued amount of money with 60% probability.



fMRI acquisition: Images were acquired on a Siemens Trio 3T scanner using an EPI sequence adapted for imaging of the orbitofrontal cortex. 33 Slices oblique to the AC-PC axis were obtained with the following parameters: 3mm slice thickness, 3x3 mm in-plane resolution, TR = 2000ms, TE = 40ms. In addition a high resolution sagittal T1 weighted image was acquired.

fMRI analysis: Data analysis was performed with SPM5. After standard pre-processing procedures were normalized to the MNI template and smoothed with a kernel of 8mm FWHM. A general linear model was computed for each individual subjects with the following contrasts of interest. Anticipation of reward (1 Euro & 20 cent) vs. No Anticipation. Win Outcome (1 Euro & 20 Cent) vs. No-Win Outcome (1 Euro & 20 cent). For statistical analysis ROIs were defined for the ventral striatum and medial orbitofrontal cortex. Mean percent signal change was extracted from these ROIs for each individual subject.

Subjects were grouped according to their scores on the scales and then compared the mean activations in reward related areas. This categorization was performed for both the BIS/BAS and AMS scales, resulting in 4 different categorizations of the subject-pool. Every categorization was then analyzed separately, using two sample t-tests in order to determine how signal change values in the ROIs are modulated by the BAS/BIS and AMS scores.

Results

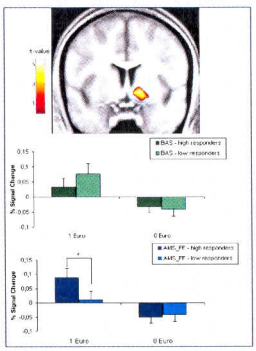


Fig. 1: Activation in the right ventral Striatum during the **expectation** of a reward

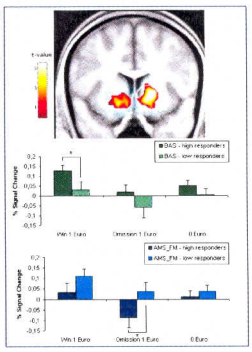


Fig. 2: Activation in the right ventral Striatum during the **receipt** of a reward

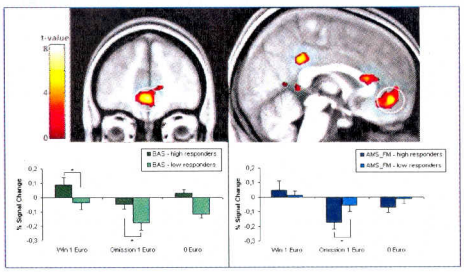


Fig. 3: Activation in the medial Orbitofrontal cortex during the **receipt** of a reward

Subjects with a high approach motivation showed more activation in the ventral striatum and the medial orbitofrontal cortex during the receipt, but not during the expectation of a reward. Furthermore, they showed less activation in the medial orbitofrontal cortex during the omission of an expected reward, and rated the reward indicating cues as less arousing.

Subjects with high inhibition motivation reacted faster when a reward was expected and showed more activation in the ventral striatum during expectation of a reward, but less activation in the ventral striatum and medial orbitofrontal cortex during outcomes.

Discussion:

Individuals with *high behavioural approach* experience a monetary gain as more pleasant than those with low behavioural approach. Our results are in line with previous studies investigating reward related neural processing in subjects suffering from ADHD (Ströhle et al., 2008), providing further proof for the relationship between overactive behavioural approach and impulsivity symptoms.

Both the elevated striatal acitivty and faster reactions observed in subjects with *high fear of failure* could indicate a general level of higher arousal in achievement related situations. Oppositely, they could perceive outcomes as more unpleasant than subjects with low fear of failure (Knutson et al., 2003). Correspondingly, a high behavioural inhibition tendency has been identified as a vulnerability factor for depression and anxiety (Johnson et al., 2003).

In conclusion, these findings are in line with prior observations, linking overactive behavioural inhibition with anxiety and overactive behavioural approach with attention deficits. Therefore, this spectrum of behavioural tendencies is also relevant in normal, non-pathological responses to reward and reward anticipation, and should be taken into account when investigating neural processing of reward.

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