



Anhedonia in schizophrenia: Deficits in both motivation and hedonic capacity



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ABSTRACT

Anhedonia is one of the core negative symptoms of schizophrenia that affect the ultimate outcome of this disorder. It is unclear whether the motivational or the hedonic component of anhedonia is impaired in patients with schizophrenia. This study examined the deficits in motivation and hedonic capacity in patients with schizophrenia using an Effort-based pleasure experience task (E-pet). Twenty-two schizophrenia patients with prominent negative symptoms, 18 schizophrenia patients without prominent negative symptoms and 29 healthy controls participated in the present study. All of them were administered the E-pet task, which required the participants to make decisions on whether to choose a hard or easy task based on probability and reward magnitude. When making the grip effort allocation decision, schizophrenia patients with prominent negative symptoms were significantly less likely to choose a hard task than healthy controls. As the reward magnitude and the estimated reward value increased, unlike healthy controls, schizophrenia patients with prominent negative symptoms did not increase their hard task choices. They were also significantly less likely to choose a hard task than healthy controls in medium and high probability conditions. When anticipating potential rewards, these patients reported significantly less anticipatory pleasure than healthy controls, even when reward probability and magnitude increased. The pleasure experience rating after obtaining the actual reward was positively correlated with two pleasure experience scales in schizophrenia patients. In conclusion, patients with schizophrenia, especially those with prominent negative symptoms, showed deficits in both reward motivation and anticipatory pleasure experience.

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1. Introduction

Anhedonia is one of the core negative symptoms of schizophrenia and is traditionally defined as the inability to experience pleasure or reduced hedonic capacity (Watson and Klett, 1970; Snaith, 1993). Gard et al. (2007) proposed that hedonic capacity can be separated into two components, namely anticipatory and consummatory pleasure. Using the Temporal Experience of Pleasure Scale (TEPS) (Gard et al., 2006), a growing body of evidence suggests that patients with schizophrenia have deficits in the anticipatory rather than the consummatory component of pleasure experience (Gard et al., 2007; Chan et al., 2010; Kring and Barch, 2014; Mote et al., 2014). However, when rating emotional valence and arousal of pleasurable stimuli, patients with schizophrenia showed blunted valence but normal arousal (Dowd and Barch, 2010), which suggests that they may also have deficits in consummatory pleasure experience. Furthermore, Strauss et al. (2011)

found that patients with schizophrenia exhibited significant impairment in consummatory pleasure but not anticipatory pleasure. The different results may be related to whether the measured hedonic capacity is 'state' or 'trait'. A meta-analysis showed that patients with schizophrenia had deficits in trait hedonic capacity but not state hedonic valence and arousal ratings (Yan et al., 2012). Given these inconclusive results, we investigated anticipatory and consummatory pleasure experience in schizophrenia patients using both trait and state measurements.

More recently, research in anhedonia has shifted from investigating reduced hedonic capacity alone to both amotivation and reduced hedonic capacity (Kring and Barch, 2014). Amotivation could be operationalized into goal-directed behavior (William, 1961) and effort allocation decision-making to pursue a potential reward (Fervaha et al., 2013a). Previous studies have shown that patients with schizophrenia tended not to exert more effort in high reward tasks due to underestimation of reward value and overestimation of effort cost (Treadway et al., 2009; Treadway and Zald, 2011). Furthermore, patients with schizophrenia failed to utilize reward magnitude and probability information (estimated value, EV) to guide reward-seeking or risk-averting behavior (Brown et al., 2013; Treadway et al., 2014). All these studies

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support the notion that anhedonia not only reflects reduced hedonic capacity but also a failure in allocating effort for reward. Thus, we also investigated deficits in hedonic capacity and reward motivation in patients with schizophrenia.

In addition, it has been suggested that negative symptoms in schizophrenia may impede effort allocation in high reward magnitude and high probability situations (Kurniawan et al., 2010; Fervaha et al., 2013b; Barch and Treadway, 2014). Patients with the most severe negative symptoms tended to be least likely to choose high cost tasks when the payoff was the greatest (Gold et al., 2013). The effect of estimated value (EV: reward magnitude \times reward probability) has been found to be negatively correlated with negative symptoms (Treadway et al., 2014). The degree of effort discounting in decision-making may also be negatively correlated with apathy in schizophrenia patients (Hartmann et al., 2014). Moreover, negative symptoms were inversely associated with motivational decision-making and anticipatory pleasure experience in schizophrenia (Mote et al., 2014; Treadway et al., 2014). Given these findings, we hypothesized that schizophrenia patients with prominent negative symptoms (negative SCZ) would have the greatest deficit in reward motivation and would not increase their hard task choices even if reward magnitude and probability increase. For hedonic capacity, since there is no evidence that consummatory pleasure experience is affected by negative symptoms (Gard et al., 2007; Chan et al., 2010), we hypothesized that negative SCZ would report significantly less pleasure experience than non-negative SCZ when anticipating a potential reward rather than after actually obtaining the reward.

The physical effort measurement in most previous studies was the speed of single finger tapping which may be affected by negative symptoms (Jogems et al., 2001). Among a number of alternative measures, grip effort has been shown to be signaled by the putamen for choices that involves effort cost (Waugh and Gotlib, 2008; Kurniawan et al., 2010), and some researchers have suggested that it is less likely to be affected by negative symptoms than finger tapping (Lafargue et al., 2006; Docx et al., 2015). Thus, we used grip effort to measure effort allocation decision-making and hedonic capacity towards potential reward in one of the tasks. Overall, we hypothesized that negative SCZ would be less likely to choose hard tasks and would experience less anticipatory pleasure compared with non-negative SCZ and healthy controls. We further hypothesized that probability and reward magnitude would influence cost/benefit decision making and anticipatory pleasure experience in schizophrenia patients and interact with negative symptom severity.

2. Method and materials

2.1. Participants

Forty patients with schizophrenia were recruited from the outpatient clinic of the Changsha Schizophrenia Hospital in Changsha of China. All patients met the diagnostic criteria for schizophrenia according to DSM-IV (APA, 1994). Inclusion criteria were 1) ≤ 50 years; 2) ≥ 9 years of education; 3) no central nervous system disorders; 4) no drug abuse or brain injury history. Negative SCZ patients must meet at least one of the following criteria on the Positive and Negative Syndrome Scale (PANSS) (Kay et al., 1987): 1) Baseline score ≥ 4 (moderate) on at least three, or ≥ 5 (moderately severe) on at least two negative PANSS subscale items (Kinon et al., 2006; Stauffer et al., 2012); 2) PANSS negative subscale score ≥ 6 points over PANSS positive subscale score (Olie et al., 2006). Patients who meet either of these criteria were classified as negative SCZ, while the remaining participants were classified as non-negative SCZ. For comparison, 29 healthy controls were recruited from the community. They were matched with the patients in age, years of education and estimated IQ measured by the Wechsler abbreviated scale of intelligence (Hays et al., 2002) (Table 1). Potential control participants were excluded if they had a history of head injury, neurological disorder, psychiatric disorder or

substance abuse. Ethics Committee of the Institute of Psychology, the Chinese Academy of Sciences approved the experiment protocol. All participants gave written informed consent before commencement of the study.

2.2. Behavioral measures

2.2.1. Grip pre-test

The task consisted of a grip pre-test and a formal test. In the grip pre-test, participants were required to grasp a grip handle three times. A meter was presented to show the change in grip strength. We adopted the strongest grip as the final parameter to define the boundary between easy and hard tasks (see Fig. 1 left).

2.2.2. Formal test: effort-based pleasure experience task (E-pet)

In the formal test, participants were required to choose between a hard task (acceptable level: 75% of the strongest grip in the pre-test) or an easy task (acceptable level: 25% of the strongest grip in the pre-test) to win monetary rewards and they subsequently rated their anticipatory and consummatory pleasure experience on a nine-point Likert scale (Fig. 1). For all trials, to be eligible for the potential reward, participants had to grip the handle until the red filler passed the acceptable level in one go. In the easy task, participants could win ¥0.5 or more within a range of ¥0.5–¥1 if their grip strength reached the space between the acceptable level (the solid line) and the strongest grip level (the dotted line). Unlike one range level in the easy task, successful performance in the hard task would entail a potential reward of either ¥1.5–¥2.4 (“low reward magnitude”) or ¥5–¥8 (“high reward magnitude”). Participants were told that a reward was not guaranteed even if they completed the grip task. In each trial, one of three levels of probability (high: 88%, medium: 50%, low: 12%) was provided before the participants made their decisions according to the probability and the reward magnitude (decision-making phase). Fig. 1 illustrates the trial procedure. After a fixation of 2 s, a meter appeared indicating the participants' variation of grip strength. If the participants made enough effort within 4 s to pass the acceptable level, they were asked to rate how happy they were when anticipating the potential reward (anticipatory pleasure experience phase) on a nine-point Likert scale. The “anticipatory reward” was the potential monetary reward that the participants wished they could win before the hard/easy grip task began. If the participants failed to complete the task, the trial would end. Following task completion, participants were presented with the actual reward (“obtained reward”) and were again asked to rate how happy they were in the moment (consummatory pleasure experience phase) on a nine-point Likert scale. The obtained reward was the monetary reward that the participants actually “won” within the defined range of reward magnitude (easy: ¥0.5–¥1; difficult: ¥1.5–¥2.4 or ¥5–¥8). Thus, the task was designed to consist of 2 reward magnitudes (low vs. high) \times 3 reward probabilities (88%, 50%, 12%), with each trial reappearing seven times, resulting in a total of 42 trials.

2.3. Other assessments

The Positive and Negative Syndrome Scale (PANSS) (Kay et al., 1987) was used to assess the symptom severity of patients with schizophrenia. The Scale for the Assessment of Negative Symptoms (SANS) (Andreasen, 1982) was used to assess the level of negative symptoms. The Abnormal Involuntary Movement Scale (AIMS) (Lane et al., 1985) and the Simpson-Angus Scale (SAS) (Simpson et al., 1979) were used to assess medication side effects.

The Revised Chapman Physical Anhedonia Scale (RCPAS) and The Revised Chapman Social Anhedonia Scale (RCSAS) were used to measure participants' pleasure experience from physical stimuli like food, sex and settings (e.g., “I have always had a number of favorite food.”) and interpersonal interaction (e.g., “Getting together with old friends has been one of my greatest pleasures”) (Chapman et al.,

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