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# Anhedonia reflects impairment in making relative value judgments between positive and neutral stimuli in schizophrenia

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ABSTRACT

Anhedonia (i.e., diminished capacity to experience pleasure) has traditionally been viewed as a core symptom of schizophrenia (SZ). However, modern laboratory-based studies suggest that this definition may be incorrect, as hedonic capacity may be intact. Alternative conceptualizations have proposed that anhedonia may reflect an impairment in generating mental representations of affective value that are needed to guide decision-making and initiate motivated behavior. The current study evaluated this hypothesis in 42 outpatients with SZ and 19 healthy controls (CN) who completed two tasks: (a) an emotional experience task that required them to indicate how positive, negative, and calm/excited they felt in response to a single emotional or neutral photograph; (b) a relative value judgment task where they selected which of 2 photographs they preferred. Results indicated that SZ and CN reported similar levels of positive emotion and arousal in response to emotional and neutral stimuli; however, SZ reported higher negative affect for neutral and pleasant stimuli than CN. In the relative value judgment task, CN displayed clear preference for stimuli differing in valence; however, SZ showed less distinct preferences for positive over neutral stimuli. Findings suggest that although in-the-moment experiences of positive emotion to singular stimuli may be intact in SZ, the ability to make relative value judgments that are needed to guide decision-making is impaired. Original conceptualizations of anhedonia as a diminished capacity for pleasure in SZ may be inaccurate; anhedonia may more accurately reflect a deficit in relative value judgment that results from impaired value representation.



## 1. Introduction

Anhedonia has long been considered a core clinical feature of schizophrenia (SZ) (Bleuler, 1911; Kraepelin, 1919; Rado, 1953). However, modern empirical research calls into question whether the traditional conceptualization of anhedonia as a diminished capacity to experience pleasure accurately characterizes the nature of affective abnormalities in SZ (Barch and Dowd, 2010; Gold et al., 2008; Kring and Elis, 2013; Strauss and Gold, 2012). Specifically, during laboratory-based studies where participants are directly exposed to various types of pleasant stimuli (e.g., complex photographs, food, social interactions), people with SZ report levels of valence and arousal that are comparable to healthy controls (CN) (for meta-analyses see Cohen and Minor, 2010; Llerena et al., 2012). Several real-world experience sampling studies also indicate that people with SZ report increases in positive emotion that are comparable to CN when engaged in activities (Gard et al., 2007; Oorschot et al., 2013). Such findings have led some to suggest that anhedonia should be reconceptualized in SZ and no longer considered a diminished capacity to experience pleasure (Barch and Dowd, 2010; Cohen et al., 2011; Gold et al., 2008; Kring and Elis, 2013; Kring and Moran, 2008; Strauss and Gold, 2012).

An important question that has yet to be answered is why apparently normal hedonic responses do not translate into a normal frequency of reward-seeking behavior in SZ (Gard et al., 2014; Myin-Germeys et al., 2000). One possibility is that SZ patients have impairments in making "relative" value judgments that are needed to effectively guide decision-making. In most laboratory-based studies, participants are asked to make "absolute" value judgments, i.e., to report how positive they feel in response to a single stimulus. However, in most real-life situations, value is not assigned in absolute terms. Rather, the value of a stimulus is typically determined in relative terms after being considered alongside other stimuli. For example, at an ice-cream parlor, one might sample a spoonful of mint chocolate chip ice cream and a spoonful of vanilla ice cream prior to deciding which of these two options to select. The value of one option may increase or decrease as it is considered in relation to the other options that have been sampled. The ability to make nuanced distinctions between two or more stimuli has been associated with the orbitofrontal cortex (OFC), which is critical for encoding relative rather

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than absolute value (Fellows and Farah, 2007; Wallis, 2007a, 2007b; Wallis and Miller, 2003). Given that structural and functional abnormalities of the OFC are well documented in SZ (Avsar et al., 2013; Barch and Dowd, 2010; Nakamura et al., 2008; Ohtani et al., 2014; Shenton et al., 2001) it is plausible that SZ patients would be impaired at making relative value judgments.

In a prior study (Strauss et al., 2011), we examined this possibility by administering a well-validated test of preference transitivity (Fellows and Farah, 2007). Participants viewed a series of photographs within a given category of mildly pleasant stimuli (e.g., puppies, fruit) and were simply asked to select which of 2 simultaneously presented visual stimuli they preferred. From these individual selections, a preference hierarchy was formed that rank-ordered individual stimulus preferences of each participant. Transitivity among preferences (e.g., if a subject prefers A over B and B over C, then they should prefer A over C) was calculated, and instances where transitivity was violated reflect impairments in making relative value judgments. Results indicated that participants with SZ violated the rules of transitivity significantly more often than CN, and these violations were of greater magnitude. Furthermore, increased severity of anhedonia was associated with a greater number and magnitude of transitivity violations. Thus, findings suggested that SZ patients display impairment in making relative value judgments and that these deficits were associated with self-reported anhedonia.

In the current study, we extended our prior experiment (Strauss et al., 2011) in several important ways. First, we had participants make preference judgments among pairs of stimuli that were rank-ordered in valence, not by the participant's own hierarchy, but by normative ratings from the International Affective Picture System (Lang et al., 2008). Second, whereas our prior study primarily allowed us to determine whether participants with SZ have deficits in making relative value judgments between pairs of mildly pleasant stimuli, this design allowed us to systematically pair stimuli within the same valence range and stimuli from different valence ranges to determine whether deficits in making relative value judgments cause stimuli from different categories to be less discriminable. Third, we directly compared preferences for social and non-social stimuli within the same valence range, as there has been some indication that anhedonia may primarily arise in relation to social stimuli or contexts (Blanchard et al., 2001; Cohen et al., 2011). This design therefore allowed us to examine whether impairments in making relative value judgments were primarily driven by reduced preference for social stimuli. Fourth, we also had participants make standard "absolute" value judgments, where they indicated how positive, how negative, and how calm/excited (i.e., arousal) they felt when exposed to a single social or non-social stimulus. Separate ratings of how positive and how negative participants felt in response to each stimulus were obtained because positivity and negativity are not diametric opposites (Larsen et al., 2001). Rather, they are separable and partially distinct components of the affect system that can be experienced simultaneously, allowing co-activations of positive and negative emotion to occur (Norris et al., 2010). The inclusion of absolute and relative value judgment tasks within the same experiment allowed us to directly test a hypothesized dissociation between intact absolute judgments and impaired relative value judgments, which has only been inferred in past studies (Strauss et al., 2011).

The following hypotheses were made: 1) During the absolute value judgment phase, SZ and CN would display comparable ratings of how positive they felt in relation to pleasant and neutral stimuli; however, SZ would report greater experience of negative emotion to neutral and pleasant stimuli (Cohen and Minor, 2010). No differences in self-reported negative emotion to unpleasant stimuli were expected; however, based on prior studies (Trémeau et al., 2009), we expected SZ to report more positive emotion to unpleasant stimuli than CN; 2) Based on the meta-analysis by Llerena et al. (2012), arousal ratings were not expected to significantly differ between SZ and CN for pleasant and unpleasant, but SZ were expected to have higher arousal ratings for neutral stimuli; 3) To evaluate a "social-specific" anhedonia deficit (Cohen et al., 2011), we compared social and non-social stimuli for self-reports of positive emotion, negative emotion, or arousal in the absolute judgment phase. These analyses were exploratory (i.e., directionality was not predicted) because it is unclear whether static images are really social in nature, or if they just convey social meaning; 4) SZ would display deficits in the relative value judgment task (Strauss et al., 2011), particularly while discriminating between pleasant and neutral stimuli; 5) Reduced preference for pleasant over neutral stimuli would be associated with greater severity of anhedonia in the SZ sample (Strauss et al., 2011).

## 2. Method

### 2.1. Participants

Participants included 42 individuals meeting Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM–IV–TR: American Psychiatric Association, 2000) criteria for schizophrenia or schizoaffective disorder (SZ) and 19 healthy controls. Individuals with SZ were recruited from the outpatient research program at the Maryland Psychiatric Research Center and evaluated during periods of clinical stability as determined by a minimum of 4-weeks of consistent medication dose and type. Consensus diagnosis was established via a best-estimate approach based on psychiatric history and multiple interviews and subsequently confirmed using the Structured Clinical Interview for DSM-IV (SCID: First et al., 1997), All patients met DSM-IV lifetime diagnostic criteria for schizophrenia or schizoaffective disorder and were prescribed antipsychotic medications at the time of testing (see Table 1).

Healthy control subjects (CN) were recruited through random-digit dialing and word of mouth among enrolled participants. All CN underwent a screening interview, including the SCID-I and SCID-II (Pfohl et al., 1997) and did not meet lifetime criteria for a psychotic disorder or any current Axis I or II disorder. CN also had no family history of psychosis. The SCID was used to determine that both SZ and CN participants did not meet DSM-IV criteria for substance abuse or dependence over the past 6 months, and lack of recent substance use was confirmed by urine toxicology at the time of testing. All participants were also screened for lifetime neurological disorders and were free from neurological conditions (e.g., traumatic brain injury, epilepsy).

**Table 1**
Demographic characteristics of sample.

| | SZ ($n = 42$) | CN ($n = 19$) | Test statistic, $p$-value |
|---|---|---|---|
| Demographics | | | |
| Age | 43.8 (11.5) | 42.8 (9.11) | $F = 0.12$, $p = 0.73$ |
| Participant Education | 12.9 (2.05) | 15.0 (1.86) | $F = 14.06$, $p < 0.001$ |
| Parental Education | 13.4 (2.05) | 14.5 (2.42) | $F = 2.71$, $p = 0.11$ |
| % Male (n) | 66.7% (28) | 63.2% (12) | $\chi^2 = 0.07$, $p = 0.79$ |
| Race % (n) | | | $\chi^2 = 1.94$, $p = 0.59$ |
| Caucasian | 90.5% (38) | 100.0% (19) | |
| African-American | 4.8% (2) | 0% (0) | |
| American-Indian | 2.4% (1) | 0% (0) | |
| Mixed-Race | 2.4% (1) | 0% (0) | |
| Symptoms | | | |
| BPRS Positive | 2.4 (1.1) | – | |
| BPRS Negative | 2.2 (1.1) | – | |
| BPRS Disorganized | 1.5 (0.4) | – | |
| BPRS Total | 38.4 (9.5) | – | |
| BNSS Total | 25.4 (17.3) | – | |
| BNSS Anhedonia | 1.8 (1.2) | – | |
| LOF Total | 18.8 (7.6) | – | |

Note: SZ = schizophrenia; CN = control. SZ were prescribed a variety of antipsychotic medications, either alone (clozapine, $n = 12$; risperidone, $n = 7$; haloperidol, $n = 3$; ziprasidone, $n = 3$; fluphenazine, $n = 2$; haloperidol decanoate, $n = 2$; olanzapine, $n = 2$; aripiprazole, $n = 1$; chlorpromazine, $n = 1$; quetiapine, $n = 1$; thioridazine, $n = 1$) or in combination with another antipsychotic (clozapine and risperidone, $n = 4$; clozapine and haloperidol, $n = 1$; clozapine and quetiapine, $n = 1$; haloperidol, aripiprazole, $n = 1$).

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