

In support of Bleuler: Objective evidence for increased affective ambivalence in schizophrenia based upon evocative testing

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ABSTRACT

Background: Ambivalence and anhedonia have long been identified as schizophrenic symptoms. However, ambivalence has rarely been studied, and in most evocative studies, schizophrenia participants are not anhedonic. Affective neurosciences posit two evaluative systems (one for Positivity and one for Negativity), the coactivation of which produces ambivalence, and point to two asymmetries in affective processing: Positivity Offset (which measures our capacity to explore the environment) and Negativity Bias (a measure of reactivity to intense threat). These characteristics have not received much attention in schizophrenia research.

Methods: Sixty-four individuals with schizophrenia and 32 non-patient control participants completed an evocative emotional task with pictures, sounds and words of various valences and intensities. Following each presentation, participants rated the level of pleasantness, unpleasantness, and arousal elicited by the stimulus. Finally, participants completed questionnaires on anhedonia, and practical life skills were assessed.

Results: Schizophrenia participants showed higher levels of ambivalence, greater arousal, greater Positivity Offset, and non-significantly different hedonic capacities and Negativity Bias. Ambivalence to positive stimuli significantly correlated with duration of illness, current level of psychopathology, anhedonia questionnaires and practical life skills. Schizophrenia patients with negative symptoms did not differ from patients without negative symptoms on computer tasks.

Conclusions: Ambivalence is greater in schizophrenia, and can be understood as a de-differentiation of the activation of the two evaluative systems. Ambivalence to positive stimuli, which may reflect early-stage affective processing is associated with impairments in higher-level emotional processes and in everyday functioning. Future studies should clarify the status of anhedonia in schizophrenia.

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“Once, I felt joy, but it was not pleasant.”

By Study Participant

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1. Introduction

Kraepelin and Bleuler described symptoms reflecting emotional deficits in schizophrenia including *absence of emotions* and *ambivalence* (defined as “the tendency...to endow the most diverse psychisms with both a positive and negative indicator at one and the same time” by Bleuler, 1950, p.53). The fate of these two symptoms diverged in the history of psychiatry (Berrios and Olivares, 1995; Raulin and Brenner,

1993). Since the 1980s, anhedonia, defined as the incapacity to experience pleasure from pleasurable activities, has been considered a core negative symptom (Andreasen, 1989) and researched extensively using clinical ratings. In contrast, the role of ambivalence has been studied to only a limited degree. Further, the role of anhedonia in schizophrenia has been challenged in evocative studies. Recent advances in the field of affective neuroscience provide updated approaches for assessment of both affective ambivalence and anhedonia using evocative testing (Cohen and Minor, 2008).

In evocative laboratory studies, participants are all exposed to the same stimulus (such as videoclips, pictures, or food) and report on their immediate emotional experience. The vast majority of evocative studies report no differences in the emotional and pleasurable experiences between individuals with schizophrenia and control participants (Trémeau, 2006; Kring and Moran, 2008; Cohen and Minor, 2008), even with patients with negative symptoms (Berenbaum and Oltmanns, 1992; Schlenker et al., 1995; Earnst and Kring, 1999), suggesting that schizophrenia subjects are not anhedonic. However, recent reviews (Kring and Moran, 2008; Cohen and Minor, 2008) have highlighted methodological shortcomings and made specific recommendations: 1) sample sizes should be more meaningful (only one study enrolled more than 50 schizophrenia participants Habel et al., 2000), 2) stimuli of different modalities and of various intensities should be used, 3) gender differences should be examined, and 4) diagnostic subgroups, and especially negative symptom schizophrenia should be compared.

Self-report measures of anhedonia, such as the Revised Physical Anhedonia Scale and the Revised Social Anhedonia Scale (Chapman and Chapman, 1978; Eckblad et al., 1982) were developed to measure individual differences in the capacity to experience pleasure from sensory sources and from social interactions respectively (see Horan et al., 2006b), and individuals with schizophrenia regularly score higher than controls on these questionnaires (Trémeau, 2006; Horan et al., 2006b). These results are difficult to reconcile with evocative study results. Moreover, although evocative tasks and self-report questionnaires are presumed to measure the same hedonia construct, only moderate correlation coefficients between these two measuring methods have been found (Horan et al., 2006a; Herbener et al., 2007; Burbridge and Barch, 2007). Discrepancies between evocative studies and questionnaires studies have various explanations: 1) the construct validity of these self-report questionnaires has been questioned (Germans and Kring, 2000; Leventhal et al., 2006; Linscott, 2007), 2) authors have shown that cognitive deficits contribute to group differences when anhedonia questionnaires are used (Burbridge and Barch, 2007; Herbener et al., 2007; Heerey and Gold, 2007), 3) Kring and collaborators have hypothesized that an intact consummatory but an impaired anticipatory pleasure reactivity can be an explanatory factor (Kring, 1999; Gard et al., 2007; Kring and Moran, 2008), and finally, 4) some authors have suggested that anhedonia questionnaires are sensitive to elevated negative emotions and do not necessarily reflect attenuated positive affect reactivity (Cohen and Minor, 2008). This latter hypothesis suggests that anhedonia questionnaires are sensitive to other-than-hedonia affective processes, which we intended to explore in the current study.

Affective ambivalence has rarely been studied in schizophrenia. One study (Raulin, 1984) used a specific self-assess-

ment questionnaire for ambivalence, and found a higher degree of ambivalence in schizophrenia participants than in non-patient control participants. In evocative studies, ambivalence can be defined as the degree of unpleasantness felt from positive stimuli, and the degree of pleasantness felt from negative stimuli. Evocative studies have found that schizophrenia participants give greater unpleasantness ratings to positive stimuli than control participants (Earnst and Kring, 1999; Kring et al., 1993; Horan et al., 2006a). As affective ambivalence is a common psychological phenomenon, it is not clear whether higher ambivalence in schizophrenia has any pathological significance. Therefore, the clinical and functional significance of higher ambivalence in schizophrenia needs to be investigated.

Affective neurosciences have brought a better understanding of emotional systems and processes. One central tenet of these affective models, such as the Evaluative Space Model (Cacioppo and Berntson, 1994; Cacioppo et al., 1999), is that affective information is processed by two separate but interacting systems: one evaluative system for Positivity (for appetitive or positive features of stimuli) and one evaluative system for Negativity (for aversive or negative features of stimuli) (Cacioppo and Berntson, 1994; Watson et al., 1999). Subsequently, the coactivation of these two evaluative systems produces ambivalence. The Evaluative Space Model also helps to explain two major evaluative asymmetries in the processing of affective information. First, the Positivity Offset (PO) refers to the fact that neutral events are more frequently perceived as emotionally positive than as emotionally negative events. This has been linked to motivation and capacity to explore the environment. Second, the Negativity Bias (NB) refers to the tendency to react more strongly to intense negative stimuli than to intense positive stimuli (Cacioppo et al., 1999). This can be linked to self-preservative benefits and a predisposition to rapidly respond to and withdraw from threatening situations. These two affective functions are quite relevant to schizophrenia. PO reflects one emotional process involved in motivation, which is severely impaired in schizophrenia. Evocative studies have reported that schizophrenia participants gave higher pleasantness and unpleasantness rating scores for neutral stimuli than control participants (Kring et al., 1993; Mathews and Barch, 2004), but none of the studies specifically reported on participants' PO. NB has recently become a topic of research in schizophrenia. One form of NB was examined where participants were presented with pairs of words or pictures, and they were asked to report on their immediate induced feelings (Lee et al., 2006). With items combining a positive and a negative stimulus, non-patient control participants reported a negative feeling most of the time, suggesting the presence of a NB. Schizophrenia participants reported positive and negative feelings with similar frequencies, indicating an absence of NB. However, stimuli of high intensity only should be used to measure NB, and it is not clear if that study did so.

The aims and hypotheses of the current study were 1) to compare emotional ambivalence and hedonic capacities between individuals with schizophrenia and non-patient control subjects. Based on previous studies, we hypothesized that ambivalence but not anhedonia would differentiate schizophrenia from healthy participants; 2) to measure and compare other aspects of affect processing. We hypothesized

that schizophrenia participants would show similar levels of negative emotions. Due to scarce literature on PO and NB, this study explored group differences in PO and NB; 3) to examine associations between these early-stage emotional processes and clinical and everyday functioning measures. More specifically, we hypothesized that self-report measures of anhedonia would be moderately correlated with and predicted by hedonic reactivity and other affective processes; 4) to compare schizophrenia participants with or without negative symptoms. Based on published studies, we hypothesized that hedonic reactivity and ambivalence would not differ between schizophrenia subgroups, and PO would be lower in schizophrenia participants with negative symptoms as motivation is quite impaired in this subpopulation.

2. Methods

2.1. Participants

The present study was part of a larger study on affect processing in schizophrenia. Participants included 64 individuals with schizophrenia and 32 non-patient control participants. Schizophrenia participants were outpatients or inpatients in a research unit at the Nathan S. Kline Institute for Psychiatric Research (NKI), New York. All subjects were English-speaking and between 18 and 65 years of age, and had capacity to give consent. Diagnosis of schizophrenia was assessed using the Structured Clinical Interview for DSM-IV (SCID) (First et al., 1998). Patients with schizoaffective disorder were not included. Healthy control participants were recruited from the NKI Volunteer Recruitment Pool. They were community subjects who responded to advertisement and volunteered to participate in research studies conducted at NKI. They had no psychiatric history and no psychiatric diagnosis as assessed with the Non-patient version of the SCID. The study was approved by the local Institutional Review Board. All patients had a reading level higher than 8th grade, as assessed with the Wide Range Achievement Test.

2.2. Clinical ratings, questionnaires and everyday functioning

All participants completed the Revised Physical Anhedonia Scale and the Revised Social Anhedonia Scale (Chapman and Chapman, 1978; Eckblad et al., 1982). Schizophrenia participants were clinically assessed with the following scales: 1) the Positive and Negative Syndrome Scale (PANSS) (Kay et al., 1987), from which the total scores and the Positive Syndrome subscale scores were used; 2) the modified Scale for the Assessment of Negative Symptoms (SANS) (Andreasen, 1989), the Attention subscale was not used as attention deficits are not specific negative symptoms (Miller et al., 1993); and 3) the Montgomery-Åsberg Depression Rating Scale (MADRS) (Montgomery and Åsberg, 1979). In addition, practical life skills were evaluated with the University of California, San Diego, Performance-Based Skills Assessment (UPSA) (Patterson et al., 2008).

In order to identify patients with primary negative symptoms, the following steps were taken. First, participants with a SANS sum score less than 12 were considered as participants without negative symptoms ($n = 38$). As negative symptoms can be secondary to depression, anxiety, extrapy-

ramidal side effects, or suspicious withdrawal (Kirkpatrick et al., 1989), the following criteria had to be met for primary negative symptoms: 1) a MADRS score less than 8, 2) a Calgary Depression Scale for Schizophrenia (Addington et al., 1992) score less than 6, 3) a Simpson and Angus scale (Simpson and Angus, 1970) score not greater than 5, 4) a PANSS Anxiety score (item G2) not greater than “3” (“mild”), and 5) a PANSS Active Social Avoidance score (item G16) not greater than “3” (“mild”). Twenty-one schizophrenia participants were subsequently classified as participants with primary negative symptoms.

All raters and SCID interviewers met reliability criteria, and were blind to study performances.

2.3. Evocative tasks

One author (JTC) developed a computerized evocative emotional test (psychometric properties discussed in Ito et al., 1998 and Ito and Cacioppo, 2005) with 48 pictures from the International Affective Pictures System (Lang et al., 1999), 48 sounds from the International Affective Digitized Sounds (Bradley and Lang, 1999a) and 48 words from the Affective Norms for English Words (Bradley and Lang, 1999b). Items differed in valence (positive, negative or neutral), intensity (moderate, extreme) and arousal levels (low, high). Visual items were presented on a 16-inch screen. Participants were instructed to attend to each stimulus for its entire duration (6s) and think about how it made them feel. After each item presentation, participants gave three separate ratings: they were asked to rate how pleasant, unpleasant, and arousing the stimulus was for them, on a 1 to 5 point Likert scale. The presentation order of the three subtests was randomized. Answers were not timed.

2.4. Data analysis

For each participant and for each evocative task (visual, auditory and semantic task), the sum scores of all “pleasantness ratings”, “unpleasantness ratings” and “arousal ratings” were calculated. Four primary evocative task variables were defined and classified according to two characteristics: stimulus valence (positive or negative), and valence congruence (positive if same valence in stimulus and ratings; negative if opposite valence in stimulus and ratings). The four primary variables were named and scored as follows: 1) hedonia (positive stimulus valence, positive congruence) was the mean pleasantness rating for positive stimuli (i.e., the sum of pleasantness ratings for all positive stimuli divided by the number of positive stimuli), 2) negative emotion reactivity (negative stimulus valence, positive congruence) was the mean unpleasantness rating for negative stimuli, 3) ambivalence to positive stimuli (positive stimulus valence, negative congruence) was the mean unpleasantness rating for positive stimuli, and 4) ambivalence to negative stimuli (negative stimulus valence, negative congruence) was the mean pleasantness rating for negative stimuli. Three secondary variables were defined: 1) PO was obtained by subtracting the unpleasantness ratings from the pleasantness ratings for all neutral stimuli, divided by the number of neutral stimuli, 2) NB was the difference between the valence ratings for extremely negative stimuli and the valence ratings for extremely positive stimuli (valence ratings are defined as the

subtraction of unpleasantness score from the pleasantness score for each item), and 3) mean Arousal.

Two preliminary analyses were conducted. First, a regression analysis for each evocative test variable, with group and sensory modality (visual, auditory or semantic) as two independent variables. The interaction term, group by sensory modality, was never significant. Therefore, scores of all three sensory modalities were combined in further analyses. Second, manipulation check was analyzed. A regression analysis was conducted with rating scores (pleasantness and unpleasantness scores) as the dependent factor, and three independent factors were entered: group (schizophrenia versus control group), stimulus valence, and valence congruence. Regression analysis showed that group ($F(1, 377) = 7, p = 0.008$), stimulus valence ($F(1, 377) = 16, p < 0.0001$), valence congruence ($F(1, 377) = 436, p < 0.0001$), group by valence congruence ($F(1, 377) = 5.8, p = 0.017$), stimulus valence by valence congruence ($F(1, 377) = 33, p < 0.0001$) significantly contributed to the model, whereas group by stimulus valence, and the three way interaction term were not significant. Post-hoc analyses showed that congruent ratings were greater than non-congruent ratings for positive and negative stimuli and for both groups, confirming the validity of our evocative test.

Schizophrenia participants were compared to non-patient control participants with univariate general linear model. For each study variable (evocative task variables and questionnaire scores) a separate regression analysis was conducted.

Study scores were the dependent factor, and “group” was the principal independent factor. For the six evocative task variables, the following confounding factors were considered: gender, age and education. Effect sizes were measured with Cohen's d , and for non-significant analyses, observed power was also reported.

To compare schizophrenia participants with primary negative symptoms and patients without negative symptoms, a new set of regression analyses was conducted with the evocative task variables.

Pearson correlation coefficients were obtained between the primary evocative task variables and other variables. As PO offers a novel objective way to measure emotional motivation, and as motivation is considered a core negative symptom, we conducted correlation analyses between PO and clinical ratings of negative symptoms, and we measured PO in participants with and without negative symptoms. All tests were two-tailed, and the alpha level was set at 0.05. No correction for multiple comparisons was applied.

3. Results

3.1. Demographics and questionnaires

Groups did not differ significantly for age and gender. Individuals with schizophrenia had a lower educational level (Table 1). On questionnaires, schizophrenia participants self-

Table 1
Demographics, self-report questionnaires and clinical characteristics

	Schizophrenia group	Non-patient control group	Statistic
<i>N</i>	64	32	
<i>Demographics</i>			
Age (in years)	37 (SD: 12)	37 (SD: 13)	$F(1, 94) = 0.12, p = 0.73$
Percentage of women (number)	16% (10)	19% (6)	$\chi^2 = 0.57, p = 0.45$
Education (in years)	12 (SD: 2)	15 (SD: 2)	$F(1, 94) = 51, p < 0.0001$
Race/ethnicity: (African-American/White/Hispanic/Other)	33/19/10/2	10/15/6/1	
<i>Questionnaires</i>			
Revised Physical Anhedonia Scale	16.2 (7.6)	7.8 (4.6)	$F(1, 94) = 32.7, p < 0.0001$
Revised Social Anhedonia Scale	13 (5.7)	7.3 (5.1)	$F(1, 94) = 22.4, p < 0.0001$
<i>Clinical characteristics</i>			
Outpatients	14 (22%)	N/A	
Age at first psychiatric hospitalization	21 years (SD: 8.6)	N/A	
Duration of illness (in years)	16 years (SD: 11)	N/A	
Number of hospitalizations (number of patients)	Less than 6: 20 From 6 to 20: 31 More than 20: 13	N/A	
Number of months spent in State Hospitals (during their lifetime)	46 (SD: 72)	N/A	
Diagnostic subtypes	Paranoid: 26 Undifferentiated: 29 Residual: 9	N/A	
Antipsychotic medications	First generation: 46 Second generation: 4 Combined: 14	N/A	
PANSS Total score	77.6 (SD: 16.5)	N/A	
PANSS Positive subscale score	18.7 (SD: 6.3)	N/A	
SANS Total score (sum of four subscales)	10 (SD: 5.6)	N/A	
Montgomery–Åsberg Depression Rating Scale	4.9 (SD: 5.5)	N/A	

PANSS: Positive and Negative Syndrome Scale.

SANS: Sale for the Assessment of Negative Symptoms.

reported greater physical and social anhedonia than controls (Table 1).

3.2. Between group analyses

Results for the four main variables are represented in Fig. 1. Compared to healthy control participants, schizophrenia participants had greater ambivalence to positive stimuli (mean in schizophrenia group: 1.7, SD: 0.5; and 1.3, SD: 0.3 in controls; $F(1, 94) = 13.6, p < 0.0001; d = 0.81$) and greater ambivalence to negative stimuli (mean in schizophrenia group: 2.2, SD: 0.6; and 2.0, SD: 0.6 in controls; $F(1, 94) = 5.2, p = 0.02; d = 0.5$). Hedonia (mean in schizophrenia group: 3.3, SD: 0.8; and 3.1, SD: 0.6 in controls; $F(1, 94) = 1.3, p = 0.26; d = 0.25$; observed power = 0.20) and negative emotion reactivity (mean in schizophrenia group: 3.1, SD: 0.7; and 3.2, SD: 0.6 in controls; $F(1, 94) = 1.1, p = 0.30; d = 0.23$; observed power = 0.18) did not significantly differ between groups.

Among the secondary variables, PO and arousal were significantly higher in schizophrenia (mean PO in schizophrenia group: 0.7, SD: 0.9; and 0.3, SD: 0.4 in controls; $F(1, 94) = 6.1, p = 0.015; d = 0.54$) (mean arousal in schizophrenia group: 2.9, SD: 0.8; and 2.4 SD: 0.6 in controls; $F(1, 94) = 8.1, p = 0.005; d = 0.62$), and NB did not significantly differ between groups (mean in schizophrenia group: -0.7, SD: 3.1; and 0.3, SD: 3.4 in controls; $F(1, 94) = 2, p = 0.16; d = 0.31$; observed power = 0.29). Confounding factors (gender, age and education) were never a significant factor for any evocative test variables. For the four variables of main interest, “intensity” (moderate versus high) was a significant independent factor (higher intensity predicted higher scores on all four variables), and the interaction term,

group by intensity, was never significant. Within the schizophrenia group, outpatients did not differ from inpatients on any study variables.

3.3. Correlation analyses

Correlation analyses (Table 2) revealed that in the schizophrenia group, ambivalence to positive stimuli was significantly associated with age, duration of illness, PANSS total scores, anhedonia questionnaires and practical life skills. As age and duration of illness were highly correlated ($r = 0.71, p < 0.0001$), we conducted partial correlations to identify which variable was driving the association with ambivalence to positive stimuli. The correlation between ambivalence to positive stimuli and duration of illness remained significant even after controlling for age ($r = 0.29, p = 0.02$), whereas the correlation between ambivalence to positive stimuli and age lost significance after controlling for duration of illness ($r = 0.09, p = 0.48$).

In the schizophrenia group, hedonia, negative emotion reactivity, and ambivalence to positive stimuli were significantly correlated with anhedonia questionnaires. Subsequently, we used regression analyses with a forward selection to test the hypothesis that these three affective processes were predictors of anhedonia scales. The Revised Physical Anhedonia Scale was significantly predicted by ambivalence to positive stimuli and negative emotion reactivity ($\beta = 6.4, F = 16.7, p = 0.0001$; and $\beta = -3.5, F = 7.6, p = 0.008$ respectively), but not by hedonia ($p = 0.40$), explaining 28% of the variance. The Revised Social Anhedonia Scale was significantly predicted by ambivalence to positive stimuli and negative emotion reactivity ($\beta = 3.9, F = 9.9, p = 0.003$; and $\beta = -2.5, F = 6.4, p = 0.01$ respectively), but

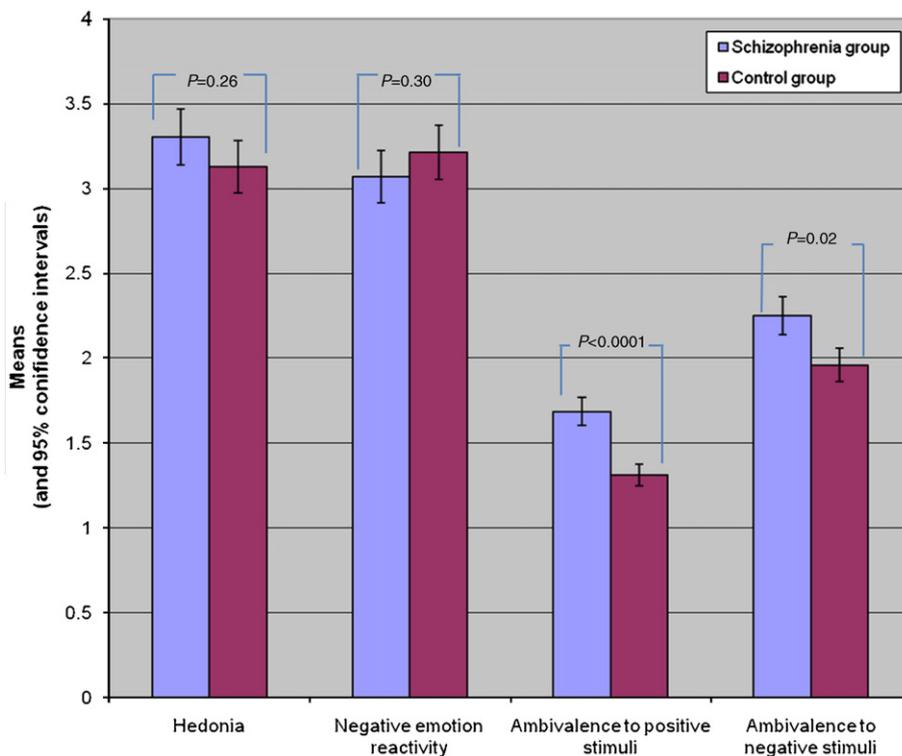


Fig. 1. Hedonia, negative emotion reactivity and ambivalence. Comparison between groups.

Table 2Correlations between primary evocative task variables and clinical variables, anhedonia questionnaires and practical life skills in schizophrenia (in bold if $p < 0.05$)

	Hedonia	Negative emotion reactivity	Ambivalence to positive stimuli	Ambivalence to negative stimuli
Age	-0.07	-0.06	0.38 $p=0.002$	0.10
Education	-0.03	-0.09	-0.18	-0.15
Duration of illness	-0.09	-0.01	0.46 $p < 0.0001$	0.12
PANSS Total score	-0.25 $p=0.046$	-0.11	0.30 $p=0.018$	-0.11
PANSS Positive score	-0.03	0.03	0.18	0.006
SANS	-0.19	-0.20	0.20	-0.01
MADRS	0.08	0.22	0.13	0.04
Revised Physical Anhedonia Scale	-0.36 $p=0.004$	-0.26 $p=0.04$	0.42 $p=0.001$	-0.06
Revised Social Anhedonia Scale	-0.32 $p=0.009$	-0.26 $p=0.04$	0.34 $p=0.007$	-0.11
UPSA	0.15	0.004	-0.35 $p=0.005$	-0.02

PANSS: Positive and Negative Syndrome Scale.

SANS: Scale for the Assessment of Negative Symptoms.

MADRS: Montgomery–Åsberg Depression Rating Scale.

UPSA: The University of San Diego Performance-Based Skills Assessment.

not by hedonia ($p = 0.48$), explaining 20% of the variance. Collinearity analyses showed that variance inflation factors were always below 2.

Positivity Offset was significantly correlated with the PANSS Negative Symptom subscale scores ($r = -0.26$, $p = 0.04$), and the SANS total scores ($r = -0.25$, $p = 0.049$), but not with any SANS subscales.

3.4. Participants with primary negative symptoms

Patients with primary negative symptoms did not significantly differ from patients without negative symptoms on any evocative task variables, on anhedonia questionnaires, and on UPSA scores. Schizophrenia participants with and participants without negative symptoms had greater ambivalence to positive stimuli (omnibus test: $F(2, 88) = 6.9$, $p = 0.002$) than controls, and these three groups did not differ on ambivalence to negative stimuli ($F(2, 88) = 2.6$, $p = 0.08$) and hedonia ($F(2, 88) = 1.7$, $p = 0.20$). With PO, the omnibus test was significant ($F(2, 88) = 5$, $p = 0.009$), and only one pairwise comparison was significant: schizophrenia participants without negative symptoms had greater PO than controls ($F(1, 68) = 9.1$, $p = 0.004$).

4. Discussion

We investigated several aspects of emotional experience in schizophrenia with the use of an evocative emotional test that used stimuli of various sensory modalities, neutral, positive and negative valences, and various intensity and arousal levels.

4.1. Ambivalence

In accord with Bleuler, our study found that schizophrenia participants were more ambivalent when presented with positive and negative stimuli than non-patient control participants. This group difference was particularly pronounced for ambivalence to positive stimuli. Evocative tests with

bivariate valence ratings (i.e., with a separate rating for pleasantness and for unpleasantness) offer an objective measure of affective ambivalence, and allow us to distinguish two forms of ambivalence that are hypothesized to rely on two functionally separable evaluative systems.

We interpreted our results as a de-differentiation between these two affective evaluative systems, that is, they are more frequently activated simultaneously. However, other explanations should be examined. The evaluative system for Negativity and/or the evaluative system for Positivity could be hyperactive. For example, schizophrenia participants may experience more negative emotions because of the cognitive demands of the tasks, or they may show differences in the temporal activation of these evaluative systems. Consequently, schizophrenia participants would give higher unpleasantness ratings for non-congruent and congruent stimuli. In our study, group differences were evidenced with non-congruent stimuli, not with congruent stimuli, which does not support the hypothesis of hyperactive evaluative system. Impairment in early emotion regulation is also a potential explanation. In order to explain a high level of unpleasant emotion with positive stimuli, Horan et al. (2006a) suggested that individuals with schizophrenia are “deficient in their ability to downregulate unpleasant emotions in the context of putatively enjoyable experiences” (p506). Our results gave some support for the existence of such a regulatory process: ambivalence to positive stimuli was lower than ambivalence to negative stimuli (the degree of negative affect induced by positive stimuli was lower than the degree of positive affect induced by negative stimuli) in both groups. However, such a regulation process cannot explain the existence of ambivalence to negative stimuli, which is best explained by a de-differentiation in early stages in emotion processing. However, these two explanations are not mutually exclusive: they both lead to a higher degree of ambivalence to positive stimuli in schizophrenia, and they may act in synergy.

Experiencing negative emotions from positive stimuli was correlated with various aspects of this illness, such as duration of illness and PANSS scores, suggesting that ambivalence to positive stimuli is an indicator of illness severity.

Pleasure or displeasure experiences reflect early stages of emotion processing (Frijda, 1999), and disruptions at these levels may lead to impairments in later-stage processes. This explains the correlations found between ambivalence to positive stimuli and anhedonia questionnaires: experiencing displeasure from positive stimuli may lead to a global impression of less pleasant experiences. Even though the process of positive stimuli is linked to well-being and social competence (Lyubomirsky et al., 2005), the correlation found in our study between ambivalence to positive stimuli and practical life skills is rather intriguing, particularly when taking into account that UPSA performances do not rely on emotional information. These results add to the existing literature on the influence of affect on social cognition/skills (Winkielman and Cacioppo, 2006), and invite for further research in schizophrenia.

4.2. Anhedonia

In accord with previous studies, 1) schizophrenia participants were not anhedonic when their emotional experiences were rated on-line, 2) schizophrenia participants had higher physical and social anhedonia with self-report questionnaires, and 3) on-line hedonia was only moderately correlated with self-report anhedonia questionnaires. Among the explanations that have been advanced for this discrepancy between evocative studies and self-report questionnaires, we tested the hypothesis that self-report questionnaires are sensitive to and predicted by other-than-hedonia affective processes. Ambivalence to positive stimuli was the best predictor for self-report anhedonia, followed by negative emotion reactivity. Surprisingly and contrary to our hypothesis, on-line hedonia was not a significant predictor for physical and social anhedonia (after the other predictors were entered).

As in previous studies (e.g., Earnst and Kring, 1999), schizophrenia participants with primary negative symptoms reported the same level of pleasure as participants without negative symptoms and control subjects. Taken together, these results mean that anhedonia as a global deficit in pleasure reactivity may not be a schizophrenic symptom, nor a negative syndrome characteristic, and different approaches and novel anhedonia subclassifications may bring interesting results (see Gard et al., 2007).

4.3. Other affective measures

Positivity Offset measures the emotional incentive salience of neutral stimuli, and is interpreted as the tendency to explore the environment and novel stimuli. In our study, schizophrenia participants had a higher PO than controls. Two other studies (Heerey and Gold, 2007; Murray et al., 2008) reported that schizophrenia participants showed higher motivation for neutral stimuli than controls, even when neutral stimuli were defined as neutral by the participants themselves. Moreover, our results are in accord with studies showing that *Novelty Seeking* is not impaired in schizophrenia (reviewed in Horan et al., 2008). However, these results seem in contrast with the clinical observation that motivation and social engagement are quite impaired in schizophrenia and more specifically in negative schizophrenia. PO reflects only one motivational process, but other motivational components may be impaired

leading to a global deficit in motivation. For example, Herbener et al. (2007) have shown that positive emotional memories lose their incentive salience over time in schizophrenia. Therefore, lack of motivation in schizophrenia may be secondary to impairments in emotional memory and not in early-stage emotional processes.

Higher PO in schizophrenia may represent a primary difference or a compensatory mechanism. The second hypothesis is favored by our correlation analyses: PO was significantly and inversely correlated with negative symptom scores, and was highest in patients without negative symptoms. This lends support to the interpretation that the incentive salience of neutral stimuli is upregulated in schizophrenia, and more so in individuals without negative symptoms. In negative schizophrenia, this upregulation seems minimal and less efficient, not leading to a normalized level of motor activity and social engagement.

Negative emotion reactivity was comparable in schizophrenia and control participants. The emotional evaluative system for Negativity was as reactive in schizophrenia as in controls. Authors have pointed out that experiencing negative emotions from negative stimuli can represent healthy emotional reactions (Lyubomirsky et al., 2005). In our study, also found by Schlenker et al. (1995), schizophrenia participants reported a higher degree of arousal. Even though a few patients had difficulty understanding the concept of affective arousal in our study, future studies adding neurophysiological and cortical measures of arousal to these subjective evaluations may reveal new findings.

Negativity bias was positive in control participants, indicating a NB effect, whereas NB was negative in schizophrenia, indicating that on average, schizophrenia participants did not show a NB effect. However this difference was not significant. Another study with a different approach (Lee et al., 2006) concluded that NB is absent in schizophrenia. As multiple paradigms can be used to test NB, other studies with different approaches would help to clarify the status of NB in schizophrenia.

4.4. Limitations

1) Groups differed in education level. However, a) study stimuli were not cognitively demanding, b) early emotional processes such as those tested in the present study, do not require extensive cognitive processes (Frijda, 1999), and c) education was not correlated with any study measures. 2) In the literature, different SANS criteria have been used to define negative syndrome. Comparison with recently published studies (e.g., Buchanan et al., 2007) shows that our SANS criteria were more selective. 3) We used operationalized criteria to differentiate primary from secondary negative symptoms, which differs from the criteria proposed by Kirkpatrick et al. (1989) in their definition of primary and deficit negative symptoms.

4.5. Conclusions

In schizophrenia, the emotional evaluative systems for Positivity and for Negativity do not appear hypo-responsive (individuals with schizophrenia are not globally anhedonic), but they are less differentiated, and get activated from opposite-

valence stimuli (individuals with schizophrenia are more ambivalent). Activation of the evaluative system for Negativity from positive stimuli is associated with clinical aspects and functional deficits of schizophrenia. The evaluative system for Positivity is relatively more activated from neutral stimuli in schizophrenia participants than in non-patient control subjects (individuals with schizophrenia have a higher PO). This can be interpreted as an upregulation of some early-stage emotional processes linked to motivation. These results further our understanding of the emotional and motivational deficits in schizophrenia, and they open the door to additional studies of early-stage emotion processing in schizophrenia.

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Contributors

Fabien Trémeau in collaboration with John Cacioppo, Pamela Butler and Daniel Javitt designed the study and wrote the protocol. Fabien Trémeau, Daniel Antonius, Rachel Zivich, Maria Jalbrzikowski, and Erica Saccente conducted the study and collected the data. Gail Silipo helped in subject recruitment. Fabien Trémeau and John Cacioppo undertook the statistical analysis. Fabien Trémeau, Daniel Antonius and Daniel Javitt wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

Conflict of interest

All authors declare that they have no conflict of interest relevant to this study.

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