Toward an Exploration of Feeling of Strangeness in Schizophrenia: Perspectives on Acousmatic and Everyday Listening

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The aim of this study was to investigate abnormal perceptual experiences in schizophrenia, in particular the feeling of strangeness, which is commonly found in patients' self-reports. The experimental design included auditory complex stimuli within 2 theoretical frameworks based on "sensory gating deficit" and "aberrant salience," inspired from conventional perceptual scales. A specific sound corpus was designed with environmental (meaningful) and abstract (meaningless) sounds. The authors compared sound evaluations on 3 perceptual dimensions (*bizarre*, *familiar*, and *invasive*) and 2 emotional dimensions (*frightening* and *reassuring*) between 20 patients with schizophrenia (SCZ) and 20 control participants (CTL). The perceptual judgment was rated on independent linear scales for each sound. In addition, the conditioning-testing P50 paradigm was conducted on 10 SCZ and 10 CTL. Both behavioral and electrophysiological data confirmed the authors' expectations according to the 2 previous theoretical frameworks and showed that abnormal perceptual experiences in SCZ consisted of perceiving meaningful sounds in a distorted manner and as flooding/inundating but also in perceiving meaningless sounds as things that become meaningful by assigning them some significance. In addition, the use of independent scales to each perceptual dimension highlighted an unexpected ambivalence on familiarity and bizarreness in SCZ compatible with the explanation of semantic process impairment. The authors further suggested that this ambivalence might be due to a conflicting coactivation of 2 types of listening, that is, every day and musical (or acousmatic) listening.

Keywords: schizophrenia, perceptual abnormalities, P50, sensory gating, aberrant salience

Abnormal perception of external stimuli constitutes an important phenomenological feature of subjective experience in schizophrenia (Uhlhaas & Mishara, 2007). In the retrospective study of

Cutting and Dunne (1989) that investigated subjective experience in patients, the most reliable feature that differentiated schizophrenia from depression was based on "perceptual anomalies." Many scales have explored and confirmed the presence of abnormal perceptual experiences in schizophrenia, such as the Structured Interview for Assessing Perceptual Anomalies (SIAPA), the Aberrant Salience Inventory (ASI), or the Cardiff Anomalous Perceptions Scale (CAPS) (Bell, Halligan, & Ellis, 2006; Bunney et al., 1999; Cicero, Kerns, & McCarthy, 2010). As shown by these scales, the common feature in the schizophrenic perceptual experience may be related to a "feeling of strangeness" or a "sensation of unusualness" (Bell et al., 2006; Cermolacce, Sass, & Parnas, 2010). This feeling is revealed by the patients' difficulties in experiencing a familiar, veridical and shareable world, which could induce a deep handicap in everyday situation. Apart from some analyses inspired by philosophical phenomenology (Blankenburg & Mishara, 2001; Cermolacce et al., 2010; Sass, 2001; Stanghellini, 2000; Wiggins, Schwartz, & Naudin, 2001), the

feeling of strangeness remains an undefined and general concept (Bell et al., 2006) largely unexplored in an experimental paradigm (Cermolacce et al., 2010).

The principal aim of this study was to better investigate this feeling of strangeness, among more general altered perceptual experiences when auditory stimuli are presented to patients with schizophrenia and control participants. To interpret the behavioral and electrophysiological results of this study, two main perspectives afford us a theoretical framework, which are inspired from the perceptual scales previously cited: the hypothesis of "sensory gating deficit" (related to SIAPA; Bunney et al., 1999) and the "aberrant salience" hypothesis (related to ASI; Cicero et al., 2010). These two frameworks will be considered as complementary.

Abnormal Perceptual Experiences and Sensory Gating Deficit Hypothesis

In their now-classic phenomenological study based on interviews, McGhie and Chapman (1961) concluded that abnormal perceptual experiences of patients were related to a primary deficit in the selective and inhibitory functions of attention. Their finding might explain that patients generally feel as if they are being flooded by an overwhelming mass of sensory input combined with a heightened sensory perception, particularly in the auditory and visual modalities (McGhie & Chapman, 1961). Since this study, it has been suggested that alterations in the neurobiological process related to filtering stimuli, focusing attention, or sensory gating may explain abnormal perceptual experiences in schizophrenia (Andreasen et al., 1994). As a consequence, schizophrenia patients may be deficient in their ability to process the relevant information and to attribute coherent meaning to sensory inputs (Braff & Geyer, 1990).

The SIAPA was inspired by these studies and particularly by the McGhie and Chapman's pioneer work (Bunney et al., 1999). For the five sensory modalities, typical Likert items, based on self-reports from patients, were assessed on three dimensions: *hypersensitivity*, *inundation–flooding*, and *selective attention to external usual stimuli*, based on self-reports of patients. They reported a significantly greater prevalence of auditory and visual perceptual anomalies in patients with schizophrenia, when compared to control subjects (Bunney et al., 1999) and confirmed the results of McGhie and Chapman (1961).

An electrophysiological paradigm was proposed to better specify the sensory gating phenomenon. In the auditory modality, the event related potential (ERP) method was used to measure sensory gating in a click-paired-stimulus (S1-S2) or *conditioning-testing P50 paradigm* (Freedman, Adler, Waldo, Pachtman, & Franks, 1983). In healthy subjects, it was found that the amplitude of the P50 component, a positive ERP component occurring around 50 ms after stimulation onset, is smaller (down to half of the value) for the second stimulus (S2) than for the first stimulus (S1) of the pair (Adler et al., 1982; Freedman et al., 1987; Freedman et al., 1983). The P50 amplitude ratio between S2 and S1 commonly serves as a measure of the auditory gating and, by extension, of the sensory gating. It is well established that this ratio is greater for schizophrenia patients than for healthy subjects, underlying deficient neural sensory gating (de Wilde, Bour, Dingemans, Koelman, & Linszen, 2007; Patterson et al., 2008). It has been proposed that two patterns may contribute to the lack of decrease

of this ratio in schizophrenia patients (Boutros & Belger, 1999; Brenner et al., 2009; Bunney et al., 1999). The first pattern is because the P50 amplitude is not reduced for stimulus S2. This gating out deficit suggests that patients might present a deficiency in the inhibitory mechanisms activated by a duplicated stimulus (S2) and consequently, in their ability to filter out redundant or irrelevant stimuli. The second pattern is because the P50 amplitude elicited by stimulus S1 is abnormally small. This gating in deficit suggests that patients might be deficient in their ability to encode and register new sensory inputs.

It was proposed that the sensory gating deficiency assessed by conditioning-testing P50 paradigm might be a good candidate for a neuronal substrate of abnormal perceptual experiences in schizophrenia further revealed by the SIAPA scale (Bunney et al., 1999; Freedman et al., 1987). However, in contrast to this assumption, Jin et al. (1998) did not find a relationship between abnormal experiences on auditory and visual items of the SIAPA and sensory gating deficits. Actually, the link between electrophysiological characterization of sensory gating anomalies by the P50 paradigm and phenomenological perceptual anomalies is still not well established and little investigated (Hetrick, Erickson, & Smith, 2010; Johannesen, Bodkins, O'Donnell, Shekhar, & Hetrick, 2008; Light & Braff, 2000). Indeed some contradictory results are found in the concerned literature, which could be explained by the difficulty in linking neurophysiological data to retrospective self-report questionnaire (Jin et al., 1998). Our study may bring some new data to better address this question.

Abnormal Perceptual Experiences and Aberrant Salience Hypothesis

Kapur (2003) suggested that abnormal perceptual experiences in schizophrenia could be explained by an aberrant salience of sensory inputs. In particular, Kapur hypothesized that an incorrect assignment of salience and significance to innocuous meaningless stimuli may constitute a central mechanism of schizophrenia (Kapur, 2003). This hypothesis was supported by patients' reports and by dysregulation of the mesolimbic dopamine system in schizophrenia patients (Heinz & Schlagenhauf, 2010).

Recently, the ASI aimed at investigating the abnormal perceptual experiences in relation with the aberrant salience hypothesis (Cicero et al., 2010). The ASI explores five factors according to 29 items, among them, the increased significance factor (evaluated by item like "Do certain trivial things ever suddenly seem epically important or significant to you?"), to which participants responded *yes* or *no*. Cicero et al. (2010) confirmed an increased attribution of meaning to external meaningless things in schizophrenia in line with Kapur's hypothesis (2003).

Our Study

The principal aim of this study was to explore the abnormal perceptual experiences in schizophrenia with the frameworks provided by the two hypotheses (sensory gating deficit and aberrant salience). Because abnormal perceptual experiences were found more frequently in auditory modality in schizophrenic patients (Bunney et al., 1999), the experimental material of this study consists in nonverbal complex sounds. We designed our sound corpus according to the two hypotheses previously presented, in a

complementary way, by collecting both *environmental sounds* and a specific class of sounds called *abstract* sounds. Environmental sounds are usual sounds that would be easily associated with a specific meaning from everyday life situations and thus be experienced as familiar. By contrast, abstract sounds are defined as unusual sounds and generally not encountered in the surrounding everyday world. They could not be easily associated with a physical sound source or a consensual meaning and be experienced as bizarre. By way of example, various terms that refer to abstract sounds can be found in the literature such as "strange" or "meaningless" (Solomon, 1958; see Merer, Ystad, Kronland-Martinet, & Aramaki, 2010, for a review). Abstract sounds were widely investigated by the electroacoustic music community, even if the term abstract was not directly used. In particular, electroacoustic music composers have developed specific recording and signal-processing techniques to avoid the clear recognition of the physical sources for musical applications. In 1966, the French composer and pioneer of "musique concrete," Pierre Schaeffer, who was both a musician and a researcher, introduced the concept of the so-called "acousmatic listening" in his book, *Traité des Objets Musicaux* (Schaeffer, 1966). Schaeffer defined acousmatic listening as the experience of listening to a sound without considering an originating cause. Abstract sounds may be considered as sounds that enhance acousmatic listening and inhibit the organization of auditory information in a coherent meaning (Merer et al., 2010; Schon, Ystad, Kronland-Martinet, & Besson, 2011).

Thus, based on the frameworks provided by the two previous hypotheses, abstract sounds (meaningless sounds) may be considered as an appropriate material to explore the aberrant salience hypothesis, in addition to environmental sounds (meaningful sounds) that may be considered as an appropriate material to explore the sensory gating hypothesis. Note that we do not exclude possible relationship between these two hypotheses based on the recent pilot study of Gjini et al. (2010) that suggested to use a battery of auditory evoked potential tests to investigate the relationship between electrophysiological measures of salience detection and sensory gating in schizophrenia patients.

The experimental design of this study was based on sound evaluation from participants following three main labels: *bizarre*, *familiar,* and *invasive*. We also included two other dimensions (labeled *frightening* and *reassuring*) related to the emotional features of the stimuli. These labels were chosen to be easily comprehensive by schizophrenic patients. The dimension bizarre corresponded to the feeling of bizarreness, nonsense, unusualness, or distortion induced by sounds. This dimension was investigated in some perceptual scales such as the CAPS (Bell et al., 2006), which included items about inherently unusual or distorted sensory experiences, such as, "Do you ever find that sounds are distorted in strange or unusual ways?" On this CAPS item, the distress, intrusiveness, and frequency of the feeling of bizarre were rated on a Likert scale. The dimension familiar corresponded to the feeling of familiarity, meaning, significance, or usualness induced by sounds. This dimension was explored by Tuscher et al. (2005), who evaluated the familiarity for environmental nonverbal sounds. The dimension invasive corresponded to the "feeling of being flooded/inundated by real sounds" as denoted by a Likert item in the SIAPA (Bunney et al., 1999). Finally, the dimensions reassuring and frightening corresponded to positive and negative feelings induced by sounds. We here preferred these labels rather than the

emotional valences commonly used in studies on emotional recognition (i.e., *pleasant* and *unpleasant*). This choice was based on considerations from informal listening pretests, which revealed that the reassuring and frightening labels were easier comprehensive than pleasant and unpleasant during the evaluation of abstract sounds.

We compared sound evaluations on these five perceptual dimensions between groups of schizophrenic patients (SCZ) and healthy subjects (CTL). The perceptual judgment was rated on independent linear scales (one scale for each dimension) for each sound through a computer interface. In addition, the conditioning-testing P50 paradigm was conducted on a subset of schizophrenic patients and control subjects.

Previous studies showed that everyday life sounds were experienced as more strange and unusual (Bell et al., 2006), less familiar (Tuscher et al., 2005), and more flooding/inundating (Bunney et al., 1999) by schizophrenic patients than by healthy subjects due to a sensory gating deficit. Thus, at a behavioral level, we hypothesized that SCZ would evaluate environmental sounds as less familiar and more bizarre. Moreover external meaningless sounds might be experienced as more significant due to an increased attribution of meaning (Cicero et al., 2010). Thus we hypothesized that SCZ would evaluate abstract sounds as more familiar than CTL. In addition, we hypothesized that both types of sounds would be perceived more invasive by SCZ.

At a neurophysiological level, we expected sensory gating deficits in SCZ evaluated by the auditory P50 paradigm based on the previous findings (de Wilde et al., 2007; Patterson et al., 2008). In particular, we expected a positive correlation between invasiveness and S2/S1 amplitude ratio (Bunney et al., 1999) and negative correlations between S1 amplitude (related to the gating in deficit) and familiarity and also between S1 amplitude and bizarreness (Brenner et al., 2009).

Finally, we assumed that hypothesized group differences found in the evaluation of bizarreness, familiarity, invasiveness, or all, might be independent of emotional dimensions. Thus, a lack of differences between groups concerning reassuring and frightening dimensions would confirm results from Tuscher et al. (2005), using a broad range of nonverbal environmental sounds.

Method

Participants

Twenty chronic in and outpatients with schizophrenia from the Department of Psychiatry of Marseille University Hospital, France, constituted the SCZ group. *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM–IV*; American Psychiatric Association, 1994) criteria based on Structured Clinical Interview for *DSM–IV* (SCID) interviews assured diagnosis of schizophrenia (First, Gibbon, & Williams, 1997). The patients' clinical severities of illness were assessed by the Scale for the Assessment of Negative Symptoms (SANS) and the Scale for the Assessment of Positive Symptoms (SAPS; Andreasen & Olsen, 1982). Scores were computed from the SANS and the SAPS for a negative symptom factor (mean of affective flattening, avolition/apathy, and anhedonia/asociality), for a psychotic symptom factor (hallucinations and delusions) and for a disorganized symptom factor (positive formal thought disorder and bizarre behavior). The

mean chlorpromazine equivalent dose was calculated according to Davis (1976).

Twenty healthy subjects screened for any current or lifetime history of a *DSM–IV* Axis I disorder based on the Mini-International Neuropsychiatric Interview (MINI; Sheehan et al., 1998) constituted the CTL group. Healthy subjects were matched to patients on the basis of age, gender, handedness (Oldfield, 1971), personal education (years), and the audition habits (hours/days of music listening and playing musical instrument or not). Demographic characteristics for both groups are shown in Table 1.

Exclusion criteria were neurological illness, brain injury, or other significant medical illnesses, current or past substance abuse or dependency, auditory impairment (assessed by a screening audiogram), and prolonged exposure to a language other than French as a child. After complete description of the study to the participants, written informed consent was obtained. The hospital's ethical committee approved the study.

Stimuli: Environmental and Abstract Sounds

We designed a representative corpus of 26 sounds to explore the five perceptual dimensions. Note that the number of sounds was limited to adapt the duration of the experience to schizophrenic patients and to avoid decline of attention and motivation during the test. For that, we started with a larger initial corpus of 199 sounds, including both environmental nonverbal sounds and abstract sounds. Environmental sounds were selected from recorded samples (which sources can be easily recognized, like sounds of animals or waves on the beach) whereas abstract sounds were selected from a sound data bank used by electroacoustic music composers obtained by particular recording techniques or sound transformations. These sounds were equalized by gain adjustments to minimize influence of loudness variations in the sound evaluation.

Then, 7 healthy participants (2 women and 5 men; mean age = 37 years old, SD = 10.80), who did not belong to the CTL, evaluated these 199 sounds on the five dimensions by using the same graphical interface designed for the subsequent formal experiment (see description in the Procedure and User Interface section). Results showed a significant negative correlation between familiar and bizarre ($r = -0.70$, $p < .05$), and between reassuring and frightening ($r = -0.56$, $p < .05$) ratings. On the basis of these correlations, we assumed that sounds could be suitably represented in a reduced orthogonal 3D space, which axes corresponded to the bipolar dimensions familiar/bizarre (*x*-axis), reassuring/frightening (*y*-axis), and to the unipolar dimension, invasive (*z*-axis). Sound coordinates along the *x*-axis (*y*-axis, respectively) corresponded to the average ratings of familiar and bizarre (reassuring and frightening, respectively). Sound coordinates along the *z*-axis corresponded to the average ratings for invasive. The 26 final sounds were selected to sample at best this 3D space. For that, we considered the virtual parallelepiped formed by the space occupied by these sounds, and we defined some target positions located on its vertices and on the median positions along its edges and faces. The sounds that were closest to these target positions (in terms of Euclidian distance) were selected. This method ensured the achievement of an optimal final corpus representative of the sound space.

The mean sound duration of the final 26 sounds was 3.66 s (SD = 1.93). Sounds were processed in digital format for standardized quality and presentation conditions (sampling frequency 44.1 kHz, 16 bit, mono). Sounds are available at http://www.lma.cnrs-mrs.fr/~kronland/Bizarre/sounds.html.

Procedure and User Interface

The experiment was conducted in a quiet room, where participants were seated in front of a PC computer screen. Sounds were randomly presented using the internal sound card of the computer and open headphones (HD650 Sennheiser) amplified with Samsom (s-type amp). Participants were free to adjust the intensity level of the sounds, once at the beginning of the test. The experimenter made sure that the sound level was high enough to provide a comfortable listening condition for each subject and that this

Table 1

Demographic and Audition Habits Data for Schizophrenic (SCZ) and Control (CTL) Groups Presented as Mean Values (±SD of the M), Except When the Population Number is Specified

Variable	SCZ (*n* = 20)	CTL (*n* = 20)	t^2	*p* value
Demographic				
Age (in years)	31.90 (6.95)	29.65 (10.87)	3.96	.440
Gender (no. of women–men)	6/14	6/14	—	1
Education (years)	6.40 (3.12)	7.80 (2.31)	2.25	.124
Handedness (no. of participants)				
Right	17	18	—	.643
Left	2	1	—	—
Mixed	1	1	—	—
Audition habits				
Music listening (hours by day)	2 hr (1.34)	1 hr 44' (0.98)	1.51	.463
Musicians (no. of participants)	6	2	—	.235
Hearing threshold (dB)				
Right	14.88 (4.42)	13.08 (3.85)	0.507	.347
Left	14.94 (4.43)	12.89 (4.25)	0.227	.231

Note. Means were compared with *t* tests (*df* = 38) and with chi-square tests for categorical variables. Hearing threshold was obtained from screening audiogram.

level was approximately set to the same value across participants in both groups. The experimenter was present with the participant during the entire test. He followed the process through his own headphones connected on the same Samsom amplifier and noted behavior and reports from the participant.

The experiment began with a six-trial training session[1] to familiarize participants with the task and to ensure the comprehension of meaning of each perceptual dimension. Then, the 26 sounds were randomly presented in a single session. Participants were asked to listen to each sound and to evaluate the familiar, bizarre, invasive, reassuring, and frightening aspects of the sound by positioning a slider on a continuous linear scale (represented by a vertical bar) associated with each perceptual dimension. Each response scale was ranged between two numeric anchors located at the extremities from 0 (*not familiar*) to 100 (*very familiar*) and the label of the perceptual dimension was displayed below the scale. A graphical user interface developed with the Max/MSP software[2] (http://www.cycling74.com/, Max/MSP) was specifically designed for this experiment. Positions of dimension labels displayed on the screen were randomly balanced across participants who could listen to the sound as many times as they wanted by clicking on the *play* button. When participants gave their five ratings of a sound, they switched to the following sound by clicking on the *next* button. Participants could return to previous ratings by clicking on the *previous* button. Although no time constraint was imposed, the experimenter verified that subjects did not dwell too much on each trial. Ratings on the five perceptual dimensions, number of times each sound was listened to, and the duration of the test were collected for each sound and for each subject.

Following the sound evaluation, participants engaged in a brief informal interview with the experimenter where they reported their possible strategies to evaluate sounds [e.g., "Did you have the feeling that you used a specific strategy? Did it happen that you gave a verbal label to sounds? Did you feel like responding before the end of the sounds? Did you feel that the perception of familiarity or bizarreness (popped out from the sounds) was immediate? or did you have to think about it?"]. During these interviews, participants were given the possibility to listen to sounds assessed during the sound evaluation.

ERP Recording

Half of the population of each group (i.e., 10 SCZ and 10 CTL) received auditory ERP recordings. The population was restricted because of the availability of the apparatus in the neurophysiology department. According to the clinical schedule, the ERP recording and the sound evaluation experiment was performed the same week. Subjects were asked to abstain from cigarette smoking for 1 hr before the electrophysiological measurements.

Auditory stimuli were delivered in a conditioning-testing P50 paradigm, consisting of a click pair presentation (conditioning click S1 followed by testing click S2) in a passive task. The interstimulus interval was set to 500 ms, and the interpair interval was set to 10 s. Clicks were rectangular pulses of 50 µs and of intensity of 100 dB SPL (Baker et al., 1987). A set of 60 stimulus pairs was delivered. Subjects were instructed to relax with their eyes closed.

Electroencephalographic activity (EEG) was monitored on a computer (EB Neuro, Inc.). EEG measurements were recorded from one electrode located on the vertex (Cz) and from two electrodes placed on left and right earlobes at 1,000-Hz sampling frequency. The EEG was referenced to the average of right and left earlobes and filtered with a bandpass filter of 1–200 Hz. Data were segmented in single trials of 1,200 ms, starting from 200 ms before the S1 onset and were averaged all together. Electrooculographic data were recorded, and trials contaminated by ocular movements and movement artifacts were rejected by visual inspection.

Statistical Analysis

Data were analyzed using STATISTICA software (Version 7.1, StatSoft). To better examine our hypotheses, we defined subsets of sounds from the initial sound corpus according to the familiar (usual) and bizarre (unusual) dimensions before conducting the statistical analyses. For that, ratings from the CTL group were averaged across participants for these dimensions and were transformed in a 26 × 26 dissimilarity matrix computed as a sound distance matrix (euclidean norm). Then, a hierarchical cluster analysis using the ward method (Schielke, Fishman, Osatuke, & Stiles, 2009) was conducted. The obtained dendrogram allowed distinguishing three clusters corresponding to subsets of sounds. The first cluster was named *environmental sounds* because these sounds were judged as most familiar and were exclusively environmental sound recordings. The second cluster was named *abstract sounds* because these sounds were judged as most bizarre and were exclusively abstract sounds. In between, the last cluster was named *intermediate sounds* because these sounds were judged no more familiar than bizarre and constituted both environmental and abstract sounds.

Then, ratings were averaged across sounds for each perceptual dimension and for each sound subset. A repeated-measures analysis of variance (ANOVA) was conducted on these averaged ratings including dimension (familiar, bizarre, invasive, reassuring, and frightening) and sound category (environmental sounds, intermediate sounds, and abstract sounds) as within-subject factor, and group (SCZ and CTL) as between-subjects factor. The sources of significant interactions between factors were further examined by *t* tests conducted for each within-subject factor separately. A repeated measures ANOVA was also conducted on the average number of times to which each sound was listened, including sound category as within-subject factor and group as between-subjects factor.

Electrophysiological data were square roots transformed to approximate the normal distributional assumptions required by para-

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[1] Six supplementary sounds were chosen in addition to the initial corpus of 199 sounds: two sounds evaluated as very familiar (described as "a bleating of a sheep" and "a Ping-Pong sound"), two sounds evaluated as not very bizarre (described as "like an electronic spring" and "like a transformative fly"), and two sounds evaluated as very bizarre (described as "a drone-like musical sound" and "a very noisy sound").

[2] The interface was tested on 3 healthy subjects and 3 schizophrenic individuals, who did not belong to the SCZ and CTL groups. We controlled that (a) they well understood the task and in particular the meaning of the five perceptual dimensions; (b) they easily answered with the interface; and (c) data were recorded, correctly stored, and easy to export toward a statistic software.

metric statistical methods. Then, data were compared between groups by t tests.

Spearman's rank-order correlation was used to examine the relationships between ratings and clinical data and between ratings and electrophysiological data in SCZ. The analyses were considered separately for each sound category, and the correlations were conducted only for ratings that were significantly different between groups (based on the results from the repeated-measure ANOVA). Clinical data were negative symptom, psychotic symptom, and disorganized symptom factors and were correlated with ratings of familiar, bizarre, and invasive. According to our expectations at electrophysiological level, correlations were analyzed between S1/S2 amplitude ratio and rating of invasive. Correlations were also analyzed between S1 amplitude and ratings of familiar, bizarre and invasive. Bonferroni correction was applied if more than one correlation test was performed.

For all analyses, effects were considered significant if the p value was equal to or less than .05 (p values were reported after the Greenhouse–Geisser correction for nonsphericity).

Results

Demographic and Clinical Data

CTL group did not significantly differ from SCZ group for the demographic and the audition habits data (t statistics in Table 1). SCZ patients were neither disorganized nor catatonic, but the following $DSM–IV$ subtypes were observed: 12 were paranoid, 4 were undifferentiated, and 4 were residual. All patients were medicated, and the neuroleptic dose was 368.58 mg per day (SD = 218.54; chlorpromazine equivalents; Davis, 1976). Five patients were on typical neuroleptics, 13 were on atypical neuroleptics, 1 was on typical and atypical neuroleptics, and 1 was nontreated.

Four patients were on anticholoinergic agents. The mean age for the first psychiatric hospitalization was 20.80 years (SD = 2.67), the mean duration of illness was 11.05 years (SD = 6.75), the total number of hospitalizations was 7.05 (SD = 6.78), and the mean total hospitalization duration was 21.92 months (SD = 42.82). The mean score to the SANS was 48.10 (SD = 24.67), the mean score to the SAPS was 42.95 (SD = 30.46), the mean negative symptom factor was 8.57 (SD = 4.62), the mean psychotic symptom factor was 10.80 (SD = 7.93), and the mean disorganized symptom factor was 7.2 (SD = 5.47).

Behavioral Data: Perceptual Experiences

No significant difference in test duration was found between SCZ (6.85 min, SD = 3.01) and CTL (8.96 min, SD = 6.28; $t^2(38)$ = 2.42, p = .13). Analysis either revealed no significant difference in the number of times each sound was listened to for each Sound category (Sound Category × Group interaction, $F(2, 76)$ = 0.55, p = .65. By contrast, ANOVA conducted on averaged ratings revealed a significant effect of the Dimension × Sound Category × Group interaction, $F(8, 304)$ = 6.65, p < .001. Because the interaction was significant, we reported results from separated analyses for each dimension and for each sound category (t statistics in Table 2).

Environmental sounds were evaluated significantly less familiar and more bizarre by SCZ than by CTL (note the exactly null rating of bizarre by all CTL subjects). Intermediate sounds were evaluated no more familiar than bizarre in both groups. Abstract sounds were evaluated significantly more familiar by SCZ than by CTL and similarly bizarre in both groups. Finally, only the category of environmental sounds was judged more invasive by SCZ than by CTL (see Figure 1). Concerning the emotional dimensions, *environmental sounds* were evaluated equally reassuring in both groups and tended to be evaluated as more frightening by SCZ

Table 2

Average Ratings Presented as Mean Values (±SD of the M) and Differences (Schizophrenia–Control [SCZ-CTL]) for Each Sound Category (Environmental Sounds, Intermediate Sounds, and Abstract Sounds), for Each Dimension and for SCZ and CTL Groups

Dimension	SCZ (n = 20)	CTL (n = 20)	Difference (SCZ–CTL)	t^2	p value
Environmental sounds					
Familiar	43.56 (30.24)	66.38 (24.96)	−22.82	6.77	.013*
Bizarre	6.77 (11.41)	0 (0)	6,77	7.05	.011*
Invasive	16.25 (22.21)	5.38 (8.01)	10.87	4.24	.046*
Reassuring	29.92 (22.03)	21.92 (20.44)	8	1.41	.241
Frightening	19.15 (16.83)	11.01 (8.07)	8.14	3.80	.058
Intermediate sounds					
Familiar	26.07 (24.62)	16.84 (16.39)	9.23	1.94	.170
Bizarre	22.84 (17.54)	17.65 (15.92)	5.19	0.95	.333
Invasive	22.48 (17.45)	16.70 (12.63)	5.78	1.43	.237
Reassuring	10.99 (12.38)	2.90 (6.69)	8.09	6.59	.014*
Frightening	22.01 (15.91)	21.65 (10.56)	0.36	.0062	.937
Abstract sounds					
Familiar	12.91 (12.92)	4.53 (8.14)	8.38	6.02	.018*
Bizarre	36.73 (18.38)	39.80 (21.15)	−3.07	0.24	.627
Invasive	31.52 (19.27)	35.72 (21.34)	−4.2	0.44	.518
Reassuring	8.24 (12.40)	1.13 (3.13)	7.11	6.18	.017*
Frightening	27.24 (22.28)	25.10 (17.20)	2.14	0.12	.735

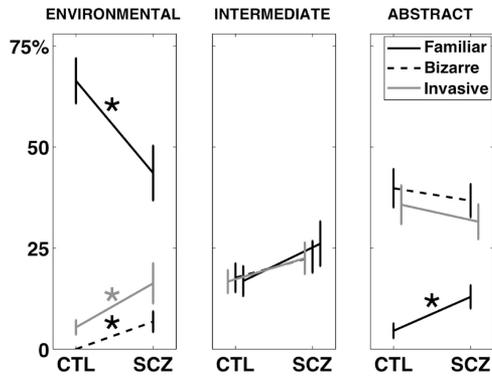*Note.* Means were compared with t tests (df = 38).
* p < .05.

Figure 1. Comparison of averaged ratings on *familiar* (solid line), *bizarre* (dotted line), and *invasive* (gray line) dimensions for the three sound categories ("environmental sounds," "intermediate sounds," and "abstract sounds") between schizophrenia (SCZ; *N* = 20) and control (CTL; *N* = 20) groups. Error bars represent the standard error. * *p* < .05.

than by CTL. Intermediate and abstract sounds were judged significantly more reassuring by SCZ than by CTL and similarly frightening in both groups.

Electrophysiological Data: Sensory Gating Inhibition

The conditioning P50 component (elicited by stimulus S1) was identified as the most positive peak between 40 and 80 ms after the S1 onset (with amplitude >0.5 μV) (Cardenas, Gerson, & Fein, 1993). The P50 component (elicited by stimulus S2) was identified in a similar way after the S2 onset. The amplitudes of these components, called the S1 and S2 amplitudes, respectively, were defined as the difference between the peak of the P50 and the immediately preceding negative peak (Boutros & Belger, 1999). No significant difference was found on the S1 amplitude (SCZ = 2.17 μV, *SD* = 1.29; CTL = 2.52 μV, *SD* = 1.66), $t^2(18) = 0.60$, $p = .604$, and the S2 amplitude (SCZ = 0.91 μV, *SD* = 0.91; CTL = 0.41 μV, *SD* = 0.28), $t^2(18) = 2.80$, $p = .111$, between SCZ and CTL, despite a trend in the S2 amplitude to be larger in SCZ than in CTL. There was no significant difference on the latency of the conditioning P50 (S1 latency, SCZ = 60.43 ms, *SD* = 3.11; CTL = 58.09 ms, *SD* = 3.17), $t^2(18) = 2.75$, $p = .114$, and of the testing P50 (S2 latency, SCZ = 61.67 ms, *SD* = 6.44; CTL = 59.64 ms, *SD* = 7.13), $t^2(18) = 0.46$, $p = .513$, between SCZ and CTL, despite a trend in the S1 latency to be longer in SCZ than in CTL.

In addition, a testing/conditioning ratio (noted S2/S1 ratio) was defined as the ratio between S1 and S2 amplitudes. Low ratios are assumed to reflect an inhibition of sensory gating whereas high ratios (superior to 0.5) may indicate a deficit in the sensory gating. The mean S2/S1 ratio was significantly greater in SCZ (0.46, *SD* = 0.37) than in CTL (0.19, *SD* = 0.13), $t^2(18) = 4.50$, $p = .048$, with half of the SCZ patients who presented a S2/S1 ratio greater than 0.5. By contrast, none of the CTL subject presented a S2/S1 ratio greater than 0.5.

Correlation Analysis

As previously mentioned in the Statistical Analysis section, the correlations were conducted only for ratings that were significantly

different between groups (see Table 2) in each sound category. Thus, concerning electrophysiological data, the correlation between S2/S1 ratio and invasive rating was examined for environmental sounds. In addition, the correlation between S1 amplitude and familiar rating was examined for environmental and abstract sounds. Finally, the correlation between S1 amplitude and bizarre and invasive were examined for environmental sounds (significant level at .012 after Bonferroni correction for correlation tests, including S1 amplitude).

First, S2/S1 ratio value positively correlated with the invasive rating for environmental sounds (*r* = .695, *n* = 10, *p* = .026): the more the patients present a deficiency in sensory gating measured with the conditioning-testing P50 paradigm, the more they judge environmental sounds as invasive (Figure 2A). Second, the S1 amplitude negatively correlated with the *familiar* rating for abstract sounds (*r* = −.770, *n* = 10, *p* = .009): the smaller the S1 amplitude, the more patients evaluated abstract sounds as familiar (Figure 2B). No significant correlations with S1 amplitude was found for environmental sounds.

Concerning clinical data, the correlations with familiar rating were conducted for environmental and abstract sounds. The correlations with bizarre and invasive ratings were examined for environmental sounds (significant level at .012 after Bonferroni correction). We found that the intensity of psychotic symptom factor negatively correlated with the evaluation of familiar for environmental sounds in SCZ (*r* = −.595, *n* = 20, *p* = .006). Supplementary analysis revealed that delusion was the most correlated symptom (*r* = −.591, *n* = 20, *p* = .007): the more the patients have delusions the less they evaluated environmental sounds as familiar. Clinical factors did not significant correlate with *familiar* for "Abstract sounds", and *bizarre* and *invasive* dimension for "Environmental sounds".

Discussion

The use of complex sounds allowed us to explore the "feeling of strangeness" previously described in Bell et al. (2006) and more generally abnormal perceptual experiences in SCZ. The selection of stimuli and labels was carefully conducted, and the sound clustering allowed us to accurately investigate the perception of environmental sounds (meaningful), abstract sounds (meaningless), and intermediate sounds. Perception of emotional dimensions (reassuring and frightening) was also examined to ensure that the group differences on the rating of familiar, bizarre, and invasive were not due to any associated emotional effect (Tremeau et al., 2009).

No group difference was found for intermediate sounds for familiarity, bizarreness and invasiveness, and the corresponding results would not be further discussed. By contrast, environmental sounds and abstract sounds were perceived differently by SCZ and CTL. Our findings confirmed some of our expectations according to the two complementary hypotheses presented in the introductory section. The first one (i.e., the sensory gating deficit hypothesis) suggested that abnormal experiences in schizophrenia consist in perceiving things in a distorted, unshared manner, and flooding/inundating, underlying a difficulty in encoding (gating in), or filtering (gating out) sensory inputs (Bell et al., 2006; Bunney et al., 1999). Note that the perceptual deficits observed in SCZ may be related to
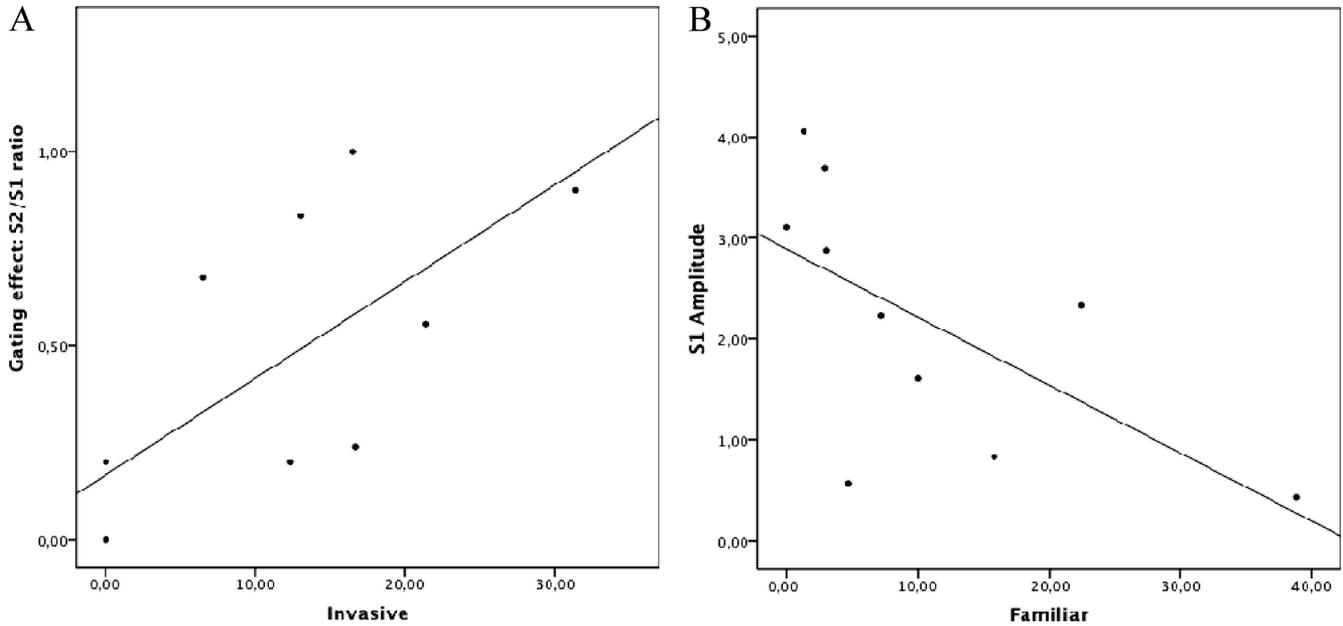
Figure 2. Electrophysiological data in 10 schizophrenic patients. A: Correlation between P50 "gating out" evaluated by the S2/S1 ratio, and evaluation of *invasiveness* on "environmental sounds." A 0 ordinate value corresponds to 100% suppression of the P50 after the second click (S2), and 1 corresponds to absence of diminution of the P50 after the second click (S2). Note that 2 patients have zero values in ordinate and abscissa. $R^2 = .466$. B: Correlation between P50 "gating in" evaluated by the S1 amplitude, and evaluation of *familiar* on "abstract sounds". $R^2 = .401$.

impairment in the processing of timbre features, leading to processing sounds in a distorted manner. This assumption was in line with our previous findings, supporting an impairment in the processing of specific timbre features for material perception (study conducted with impact sounds on metal, wood, and glass materials) in schizophrenia (Micoulaud-Franchi et al., 2011). The second hypothesis (i.e., the aberrant salience hypothesis) suggested that abnormal experiences consist in perceiving things that commonly have no particular meaning as things that become meaningful by assigning them incorrect significances (Cicero et al., 2010; Kapur, 2003). In addition, our finding brought some perspectives concerning ambivalence that may not only be related to these previous hypotheses but also more generally to the assumption that abnormal experiences may also be due to impairment in high levels of sound processing (in particular, semantic identification impairment) and to the coactivation of conflicting processes in schizophrenia.

Abnormal Perceptual Experience of Environmental Sounds

As expected, SCZ evaluated environmental sounds as less familiar, more bizarre, and more invasive than CTL. These results were in agreement with patients' perceptual reports obtained by SIAPA or CAPS, indicating that everyday life sounds seem to be experienced as distorted, unusual, nonshared, and flooding/inundating (Bell et al., 2006; Bunney et al., 1999). In addition, we found that the rating of familiar for environmental sounds was negatively correlated with the intensity of clinical symptoms (psychotic symptom factor and particularly delusion). This result was in line with previous studies, showing that anomalous perceptual experiences might enhance delusion (Bilder, Mukherjee, Rieder, & Pandurangi, 1985; Peralta & Cuesta, 1999; Peralta, de Leon, & Cuesta, 1992). Nevertheless, this aspect remains controversial and some other studies that did not report such a relationship using the CAPS (Bell, Halligan, & Ellis, 2008).

A significantly greater S2/S1 ratio (recorded from conditioning-testing P50 paradigm) was found in SCZ. Moreover, this ratio was positively correlated with the invasive rating for environmental sounds, constituting valuable arguments in favor of the sensory gating deficit hypothesis. More precisely, impairments in the sensory gating out process of irrelevant sensory inputs might cause a perceptual experience of inundation and flooding in this disease (Boutros & Belger, 1999; Brenner et al., 2009; Bunney et al., 1999). Our results contrasted with those of Jin et al. (1998), who did not find any relationship between perceptual anomalies assessed by the SIAPA and sensory gating deficit assessed by P50 recording. As in Light and Braff (2000), this difference might be explained by a deficiency of insight and self-awareness from patients' self-reports investigated by Jin et al. (1998). This study avoids such a possible drawback, because the evaluation of invasiveness was done during sound listening and thus diminishing the confounding effects of altered insight and self-awareness (Light & Braff, 2000), as well as the avoidance of perceived stigmatization (Kruck et al., 2009).

Abnormal Perceptual Experience of Abstract Sounds

As partly expected, we found that SCZ evaluated abstract sounds as more familiar but no more invasive than CTL. The overevaluation of familiarity indicated that patients might experience meaningless sounds as more significant than healthy subjects in agreement with schizophrenic individuals' perceptual reports by using the ASI scale (Cicero et al., 2010) and with the aberrant salience hypothesis developed by Kapur. This result might be accurately compared with previous ones from Nielzen, Olsson, and Ohman (1993), who demonstrated that patients judged complex nonverbal nonenvironmental sounds as more attractive than healthy subjects.

In addition, we found a negative correlation between the familiar rating for abstract sounds and S1 amplitude in SCZ. This negative correlation indicated that aberrant salience anomalies (revealed by a higher rating of familiarity for meaningless sounds) seemed to be enhanced by the deficit to gate in novel sensory inputs (revealed by the S1 amplitude decrease). Previous studies already concluded on a relationship between gating in deficit and phenomenological perceptual anomalies but remained attached to the assumption of distorted, unusual, and unshared perception in line with the sensory gating hypothesis (Hetrick et al., 2010; Johannesen et al., 2008; Kisley, Noecker, & Guinther, 2004). As a complement to these previous studies, our results also suggested a relationship between gating in deficit and emergence of aberrant saliencies in line with the aberrant salience hypothesis. Thus, our results confirmed that a better characterization of this relationship could improve the understanding of the sensory-processing abnormalities in schizophrenia (Gjini, Arfken, & Boutros, 2010).

The abstract sounds were evaluated as highly flooding similarly between CTL and SCZ. These results might be explained because the consequence of sensory gating deficit might be hidden by a saturation effect for very invasive sounds. Note that it was not the case for environmental sounds because the rating of invasive was notably lower.

Ambivalence in Abnormal Perceptual Experience

We designed the experimental protocol so that familiarity and bizarreness were evaluated in a same trial (for each sound) but separately on two distinct scales. We observed that CTL evaluated these dimensions in a quite categorical way: Environmental sounds were perceived as highly familiar and not bizarre at all (exactly null rating) and abstract sounds were perceived as mostly bizarre and almost non familiar (exact null rating for most subjects except for only a few). By contrast, we found that patients were not disturbed by evaluating sounds jointly as familiar and bizarre: Environmental sounds were mainly perceived as familiar (even if it was lower than CTL) and more bizarre than CTL; abstract sounds were mainly perceived as bizarre (similarly to CTL) and more familiar than CTL.

Beyond the two hypotheses examined in our study, we assume that these results were due to a more complex process than the ability to gate in–out relevant sensory inputs or to attribute significance to aberrant auditory saliencies. We suggested that they might be linked to the concept of "ambivalence" in schizophrenia defined as "the tendency. . . to endow the most diverse psychisms with both a positive and negative indicator at one and the same

time" (Bleuler, 1950, p. 53). Ambivalence in schizophrenia was previously demonstrated for emotional recognition processing, using calibrated stimuli of the International Affective Digitized Sounds: Patients rated positive stimuli as pleasant and negative stimuli as unpleasant similarly to healthy subjects, but at the same time they rated positive stimuli as more unpleasant, and negative stimuli as more pleasant (Lang, Bradley, & Cuthbert, 1999; Tremeau et al., 2009). This result was formally explained by the coactivation of the two emotional evaluative systems (one for positivity and one for negativity) assumed to be opposite and distinct in healthy subjects (Tremeau et al., 2009). In our study, emotional dimensions were globally well controlled since ratings of reassuring and frightening were similar in both groups for environmental sounds and almost for abstract sounds (excepted the rating of reassuring that was greater in SCZ). These results allowed us to conclude that the evaluation of bizarreness and familiarity (and also invasiveness) was not much influenced by emotional dimensions. Thus, we assumed that our result on joint and nonnull evaluation of familiar and bizarre in SCZ might even so be interpreted as ambivalence effect but not based on two emotional evaluative processing. In particular, we assumed that the observed ambivalence might be related to consequences of an impairment in the semantic process of labeling, indicating a conflicting coactivation of two types of listening,[3] that is, "everyday listening" and "musical listening" as defined by Gaver (Gaver, 1993). In our view, this last term of musical listening is close to the notion of acousmatic listening, which is used in our study.

Actually, the underrating of familiar for environmental sounds in SCZ supported the assumption of impairment in semantic process of labeling in line with previous studies. Contrary to CTL, SCZ reported that, "For all sounds, I asked myself whether I could label this sound?" indicating that the labeling may not be an automatic or easy process for them. Moreover, Tuscher et al. explained the underevaluation of familiarity for environmental sounds by patients compared to healthy subjects as a consequence of an inability to activate the appropriate representation in the internal lexicon memory when a stimulus is perceived (Tuscher et al., 2005). Wexler et al.'s (2002) study mainly focused on semantic processing and showed deficit in schizophrenia in verbal memory processes independently from sensory processing. At least, semantic impairments were found in schizophrenia both with a priming protocol in a lexical-decision task (Spitzer, 1997), and with the N400 protocol (ERP method) considered as a neurophysiological probe of activation of concepts in semantic memory (Kiang, Kutas, Light, & Braff, 2008). Going further, it was suggested that this semantic impairment in schizophrenia might be due to the development of a hyperextended semantic network as proposed by Spitzer (1997). The recourse to this network may be emphasized for abstract sounds, defined to be particularly difficult to label (even for CTL) because they could not be easily associated with a physical sound source.

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[3] Note that Schaeffer previously proposed four types of listening, that is, "hearing," "listening," "comprehending," and "understanding." Some of them were in line with the ones proposed by Gaver. The four types of listening involved subtle differentiations between cognitive processes and may not be adapted to directly support our findings.

In relation with this semantic impairment and possible sensory deficient, we suggested that SCZ might coactivate the two types of listening, that is, everyday listening and acousmatic listening, in a conflicting way. Everyday listening refers to a listening of sounds as things. Ihde wrote: "Sounds are 'first' experienced as sounds of things and it is sufficient for ordinary affairs" (Ihde, 1976, p. 60), and these things may consistently be associated with labels. Thus, everyday listening necessitates a labeling process of sounds. Acousmatic listening refers to the listening of sounds in terms of their sound quality (acoustic attributes) without paying attention to the sources. Schaeffer wrote, "Often surprised, often uncertain, we discover that much of what we thought we were hearing, was in reality only seen, and explained, by the context" (Schaeffer, 1966, p. 93). Generally, sound listening leads to switching from one type of listening to another. As detailed in the Introduction and in our previous research on healthy subjects (Petitmengin et al., 2009), "Abstract sounds" may privilege "acousmatic listening" and "Environmental sounds" may privilege "everyday listening".

On the basis of our findings concerning environmental sounds, we assumed that patients tried to label these sounds by connecting them to things using everyday listening but had difficulties in activating the appropriate labels combined with a distorted, non-shared perception that also might have led them to adopt acousmatic listening. In line with this assumption, we observed that patients had some trouble to label sounds, as shown by patients' reports, reported above. In addition, patients also reported more details concerning sound quality, such as volume, pitch, or timbre attributes, such as, "This sound of wind presents a beautiful tremolo." Concerning abstract sounds, our study showed a similar evaluation of bizarre in the two groups: We assumed that patients adopted acousmatic listening as healthy participants also might have done. Nevertheless, a possible call in the hyperextended semantic network might also have led them to activate everyday listening in a significant way, allowing them to attribute a conceivable meaning to sounds though the feeling of bizarreness was present. Some patients' reports on abstract sounds illustrated this dual aspect: "It sounds like a chirping bird, but a strange bird in a science fiction movie"; "It could be the sound of a leaky faucet, but a strange faucet." Moreover, we observed that patients consistently tried to find a plausible description of abstract sounds, by frequently referring to science fiction productions because of a lack of real-life references: "This is like the sound of a vessel in an alien movie." Finally, these results and considerations allowed us to conclude that the observed ambivalence in SCZ, in particular the overrating of bizarre for environmental sounds and the overrating of familiar for abstract sounds might be due to the simultaneous activation of these two types of listening.

Limitations

Some limitations can be attributed to our study. First, concerning the experimental design, we used a continuous linear scale ranging from 0 to 100, leading to a higher variability of response values than a discrete Likert scale. Moreover, the use of continuous linear scales may induce a different understanding of the scale rating between SCZ and CTL, meaning that the observed effects might not be solely due to abnormal perception in SCZ but rather to a systematic group difference in the anchors assumed by the two groups. However, during the training session the experimenter ensured that subjects understood the task and the meaning of the perceptual dimension in a similar way. In addition, results showed that the group difference was not significant for several perceptual dimensions and that the variances of the ratings globally were comparable in the two groups (see Table 2). We also found that SCZ rated environmental sounds as less familiar than CTL and as more familiar than CTL for abstract sounds, indicating an opposite effect along this perceptual dimension. Thus, our findings can be reasonably related to perceptual abnormalities in SCZ, hereby reducing the probability of a systematic group difference between CTL and SCZ.

Second, we did not use emotional valences usually experimented in the literature. Because we did not aim at precisely investigating the emotional recognition in schizophrenia, we did not evaluate specifically pleasant and unpleasant feelings induced by sounds. Nevertheless, we chose labels associated with the emotional dimensions that were well adapted to our sound corpus, particularly to the abstract sounds.

Third, we did not specifically analyze hypersensitivity (e.g., SIAPA-item like "real sound seem more intense or loud") or selective attention to external sounds (e.g., SIAPA-item like "cannot focus attention on one real sound by excluding the other ones"; Bunney et al., 1999). Although the design of our study was not created to explore these aspects, the related acoustic characteristics of sounds were controlled at best during the design of the sound corpus. In particular, the experimenter equalized the sound intensity level, and the coexistence of several auditory streams in a sound was minimized to control the subjects' attention. On the basis of previous studies that showed a correlation between attentional performance and sensory gating deficit assessed by P50 response (Cullum et al., 1993; Erwin, Turetsky, Moberg, Gur, & Gur, 1998; Wan, Friedman, Boutros, & Crawford, 2008), our findings concerning sensory gating deficit may also be induced by attentional deficit. However, the duration of the test and the number of times each sound was listened to, were similar between groups, allowing us to conclude that there was a lack of noticeable attentional or motivational disturbance in SCZ.

Fourth, the task conducted in this study involved multiple cognitive processes and our results cannot determine whether group differences can be related to a low level (perceptual), to a high level (cognitive and semantic) or to interactions between low- and high-level dysfunctions in schizophrenia as discussed in previous literature (Adcock et al., 2009; Bell et al., 2008; Javitt, 2009; Leitman et al., 2010). Moreover, based on Phillips and Silverstein's (2003) study, we cannot exclude an alteration in perceptual and cognitive organization and neural synchrony as a possible interpretation of group differences. Actually, this interpretation could subsequently be validated experimentally if the EEG activity reveals a decreased synchrony for environmental sounds and an increased synchrony for abstract sounds in schizophrenia compared with healthy subjects.

As a last limitation, our study suffered from a small population size. However, individual data did not show any outliers among participants, and our results are in line with the existing literature. To support our results, a larger cohort of patients is necessary, and it will be interesting to investigate patients that present emphasized abnormal experiences such as young schizophrenia patients or high-risk persons for schizophrenia (Cicero et al., 2010; Horan,

Reise, Subotnik, Ventura, & Nuechterlein, 2008; Parnas, Handest, Jansson, & Saebye, 2005; Parnas, Moller, et al., 2005).

Conclusion

The principal aim of this study was to investigate the "feeling of strangeness" suggested to be a general feature of schizophrenic perceptual experience (Bell et al., 2006; Blankenburg & Mishara, 2001; Cermolacce et al., 2010; Stanghellini, 2000). The experimental paradigm proposed in this study may be considered as a complementary approach to perceptual scales (Bell et al., 2006; Bunney et al., 1999; Cicero et al., 2010; Hetrick et al., 2010) with the advantage to be less sensitive to the effects of insight and self-awareness alteration as observed in patients' self reports (Kruck et al., 2009; Light & Braff, 2000). In addition, this was the first study to our knowledge that used abstract sounds to assess abnormal perceptual experience in schizophrenia (Merer et al., 2010; Schaeffer, 1966).

By designing a specific sound corpus and task procedure, our findings allowed us to provide arguments in favor of both sensory gating deficit hypothesis and aberrant salience hypothesis. Actually, we can conclude that the abnormal perceptual experience related to feeling of strangeness in schizophrenia is based on two processes: perceiving usual or meaningful things (i.e., environmental sounds) in an unusual or meaningless way (due to a sensory deficit) and perceiving unusual or meaningless things (i.e., abstract sounds) in a meaningful way though the feeling of bizarreness was not avoided. Results also highlighted ambivalence on familiarity and bizarreness in SCZ, with a similar evaluation of bizarre for abstract sounds between SCZ and CTL. Thus, beyond the previous hypotheses, the observed ambivalence could also be compatible with the explanation of semantic process impairment related to a hyperextended semantic network in schizophrenia. We suggested that this ambivalence was due to the coactivation of two types of listening, "everyday" and "acousmatic" listening, in a conflicting way (Gaver, 1993; Schaeffer, 1966).

In conclusion, the use of specific environmental and abstract sounds allowed us to explore perception of complex auditory stimuli in schizophrenia. This approach needs more investigations on patients' reports together with the use of electrophysiological measurement. In particular, ERPs studies offer a precise discrimination between semantic processes and sensory or perceptual processes (Aramaki, Marie, Kronland-Martinet, Ystad, & Besson, 2011; Kiang et al., 2008; Micoulaud-Franchi et al., 2011; Schon et al., 2011). Another promising domain of research consists in the exploration of the synchrony EEG activity, with a better spatial and temporal understanding of the neural discharges involved in a coherent object representation (Lachaux, Rodriguez, Martinerie, & Varela, 1999; Tallon-Baudry & Bertrand, 1999). This study and these perspectives constitute new experimental steps to tackle actual difficulties of patients with schizophrenia to experience everyday situations as familiar, veridical, and shareable.

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