Differences and similarities in the sensory and cognitive signatures of voice-hearing, intrusions and thoughts

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Abstract

Background: Auditory hallucinations are frequently conceptualized as a disorder of input, whereby random discharges in language-related cortical areas lead to sensory irritations that mimic real voices. Alternatively, auditory hallucinations may represent a disorder of interpretation, whereby none of its four prevalent characteristics (the "four A's of hallucinations": acoustic, alien (i.e., appears as non-self), autonomous (i.e., beyond subjective control), authentic (i.e., appears like a real voice)) can reliably discriminate real versus imagined voices.
Method: The study explored the resemblance between imagined (i.e., auditory hallucinations) and real voices. Further, the cognitive and sensory profiles of thoughts, intrusions/obsessions and voice-hearing were examined. To circumvent conservative response biases, an Internet study was conducted. 160 subjects completed the survey. Of these, 45 were diagnosed with schizophrenia, 55 had obsessive–compulsive disorder (OCD) and 60 were non-clinical controls.
Results: In line with prior research, most schizophrenia patients and approximately every 7th non-clinical and every 7th OCD participant reported hearing voices. The results lend support to the claim that none of the four A's of hallucinations is specific to voice-hearing and therefore challenges the assumption that this class of phenomena reflects a false but reasonable inference of anomalous input. Importantly, a large number of voice-hearers (37%) admitted that their voices did not appear very real, and that they were less loud than real voices (52%). Voice-hearers, irrespective of diagnostic status, reported greater vividness and loudness of mental events even for normal thoughts and obsessions suggesting that enhanced mental vividness, in addition to the presence of metacognitive biases, may represent vulnerability factors for the development of hallucinations.
Conclusions: Differences between intrusions and voice-hearing are more quantitative than qualitative, supporting the view that voice-hearing is more than a disorder of input. The results do not completely refute a bottom–up account of voice-hearing but suggest the involvement of important top–down attributional processes.
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1. Introduction

1.1. Definitions of hallucinations

Hallucinations, simply defined, are perceptions without an external stimulus. To differentiate true hallucinations

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from vivid imagination and "pseudo-hallucinations", more comprehensive definitions require the belief of an external agency as additional criterion. In the DSM-IV, authenticity is added as yet another feature: "a sensory perception that has the compelling sense of reality of a true perception but that occurs without external stimulation of the relevant sensory organ" (American Psychiatric Association, 1994, p. 767).

1.2. Accounts of hallucinations: a disorder of input

One prominent view of auditory hallucinations holds that random discharges in circumscribed cortical areas lead to sensory irritations that are reasonably (albeit falsely) interpreted as externally generated. Thus, hallucinations arise through some form of sensory-bound dysfunction, thus representing a disorder of input. Consistent with this bottom–up view, some neuroimaging studies have shown that primary and association auditory areas are involved in auditory hallucinations (for a recent review see Allen et al., 2008).

There are some limitations to this view. First, a considerable number of neuroimaging studies have not found auditory hallucinations to be associated with brain activation in language production areas, and disturbances in the auditory cortex are only observed in a subgroup of patients (Copolov et al., 2003; Lennox et al., 1999, 2000; Shergill et al., 2000, 2001; Silbersweig et al., 1995; van de Ven et al., 2005). Second, hallucinations are often personally and emotionally salient, that is, involve personal experiences and have emotional content rather than being entirely random phenomena. Third, although often affecting the auditory modality, hallucinations often extend to non-auditory sensory modalities that are remotely distributed over the brain. For example, up to 54% of schizophrenia patients may experience visual hallucinations (Bracha et al., 1989; Mueser et al, 1990; Phillipson and Harris, 1985). This makes the notion of a central rather than a peripheral (sensory-bound) account of hallucinations more conclusive. Finally, Frith (1999) has pointed out that some brain activation during hallucinations may be a consequence, and not a cause, of hallucinations (e.g., high arousal when hearing malevolent voices).

1.3. Accounts of hallucinations: a disorder of interpretation

An alternative view is that hallucinations are a disorder of interpretation (Morrison, 2001). This top–down or attribution-based position derives from research focusing on faulty reasoning and metacognitive beliefs, rather than on abnormalities in perceptual processing (see also Moritz et al., 2006a). According to this account, false beliefs about the controllability of voices (Morrison et al., 1995) presumably foster the misattribution to an external source. In addition, the adoption of lax or false criteria for attributing mental events to external agents may contribute to the phenomenon of voice-hearing. To illustrate, semi-acoustic cognitions and/or thoughts that seem strange and beyond control may constitute sufficient evidence for hallucination-prone individuals to assume an external (non-self) agent. In contrast, non-hallucinating individuals are mostly aware that thoughts and mental images can sometimes deviate from intentions. While such intrusions may at times give rise to the impression *as if* someone else is thinking or speaking in our mind, given intact reasoning and metacognition, intruding thoughts are nevertheless attributed to one's self. From this viewpoint, vivid mental experience is necessary but not sufficient for the apparition of hallucinations.

1.4. Characteristics of voices

Voice-hearing can be described along four characteristics (the "four A's of hallucinations") that also characterize external voices: they are acoustic, autonomous, alien and authentic external events. A question pertinent for the first account of hallucinations (a disorder of input) is the degree of resemblance between imagined and real voices. A hallucination would not be distinguishable from an external voice if it receives maximal appraisals on all four A's.

Of course, greater resemblance between hallucinated and genuine voices would favor the bottom–up explanation of hallucinations. However, there is reason to believe that hallucinations may vary in their perceived degree of reality and the presence of voice-like features. For instance, some voice-hearers acknowledge that they exert some control over the voices and can determine not only the "what" but also the "when" of the input, which is discordant with the criteria of hallucinations as alien and strictly autonomous. Also, voices are often reported to be less clear than real voices and described as mere whispers in a subgroup of patients (Nayani and David, 1996; Watkins, 1998), thus weakening the analogy to external input and raising questions why these are perceived as authentic signals at all (e.g., Watkins, 1998, p. 86).

Another question relates to the distinction among thoughts, intrusions and hallucinations, since some of the four A's of hallucinations are not confined to hallucinations but extend to other mental events. For example, intrusive thoughts are often characterized as alien and autonomous. As with hallucinations,

intrusions and obsessions are frequently experienced as ego dystonic (i.e., are experienced as inconsistent with the person's belief system) and uncontrollable, share similarities in form, content and triggers (e.g., stressful events), and are usually accompanied by subjective discomfort (Morrison et al., 1995; Morrison, 2001). The "perception" and misattribution of inner thoughts is perhaps not an exclusive feature of hallucinations: many non-clinical subjects report vivid imaginations, hearing a song or a familiar voice between their inner ears (e.g., when reading emails).

1.5. The present study

The present study intended to fill some gaps in our understanding of hallucinations and, in particular, the two accounts of hallucinations. Firstly, we aimed to investigate the extent to which voice-hearing resembles real voices. Evidence that voice-hearers characterize their voices as fully uncontrollable, autonomous, acoustic and authentic external events, would be strong support for the bottom–up account. In contrast, evidence that this is not the case would suggest that voice-hearing is more than a disorder of input and that important top–down attributional processes may be involved. Secondly, we aimed to examine whether some characteristics of voice-hearing also characterize intrusions and (normal) thoughts. In particular, we investigated the degree to which mental events, especially intrusions, are perceived as acoustic, autonomous, alien and authentic.

To meet these aims we asked schizophrenia as well as OCD patients and normal volunteers to rate the phenomenological characteristics (i.e., the 4 A's) of intrusive and non-intrusive thoughts as well as voice-hearing. We hypothesized that voice-hearing would be associated with high scores on all the four A's of hallucinations, but that in many cases hallucinations would lack voice-like properties indicating that they are also a disturbance of interpretation (such as "liberal acceptance"; see Moritz et al., 2006a), and not solely a disturbance of input. With respect to the differentiation of voice-hearing from intrusions and thoughts, we expected to replicate the finding that intrusions would also be perceived as alien and beyond control. We additionally predicted that for a substantial minority of non-psychotic individuals who do not report hearing voices, normal thoughts and intrusions would share acoustic properties. Concurrently, and based on clinical observation, it was expected that a subgroup of people reporting hearing voices would not maintain that their voices share an acoustic quality at all. This would suggest that the label "voice-hearing" may act as a mis-

nomer denoting certain cognitive phenomena as being non-self.

We tested these hypotheses using an Internet-based survey. Internet studies are more economic than standard paper-and-pencil investigations and not as likely to inhibit openness as interview-based studies. Critically, the reliability of psychopathology e-questionnaires (Jones et al., 2008) and correspondence of Internet-collected data with conventionally obtained data has been recently asserted (Riva et al., 2003; Freeman et al., 2005), including studies performed with schizophrenia samples (Chinman et al., 2004). To protect the integrity of our sampling method, multiple criteria were used to assure the reliability of the data. Importantly, the utilized software did not allow more than one entry from the same computer. Further, participants with ambiguous responses were excluded (see Section 2.1 for details).

2. Methods

2.1. Participants

The first author posted an invitation to participate in a scientific study on several moderated German-language discussion forums for OCD, schizophrenia, general psychiatric disorder and voice-hearing. Potential participants were informed that the survey was anonymous and dealt with human thinking, and more specifically with normal thoughts, thoughts considered as disturbing (such as ruminations), catchy tunes, as well as with so-called voice-hearing. The survey was only available in German. Healthy subjects were recruited via an established subject pool, and anonymity in healthy subjects was assured in the same way as for psychiatric patients.

Of the 213 subjects completing the survey, 160 participants (75%) were included in the analyses. Main reasons for drop-out were inconsistent entries across different survey sections (e.g., presence of OCD initially affirmed but later the presence of obsessions and/or compulsions were denied), implausible entries (e.g., age beyond 100), admitting not completing the survey honestly, and psychiatric diagnoses other than schizophrenia or obsessive–compulsive disorder (e.g., attention deficit disorder, bipolar disorder). Participants were blindly categorized into three groups based on the below criteria.

Participants were allocated to the healthy control group ($n=55$) if they: (1) denied the presence of any psychiatric illness, (2) did not take any psychotropic substances and (3) negated any contact with psychological or psychiatric institutions for psychological

problems. Participants were allocated to the OCD group ($n=60$) if they: (1) connected from an OCD web-site, (2) confirmed a prior diagnosis of obsessive–compulsive disorder by a mental health professional (physician or psychologist), (3) affirmed the presence of checking or washing compulsions (i.e., participants with other compulsions were excluded), (4) filled out the Y-BOCS which again requested confirmation of the presence of OCD symptoms (mean=16.13, SD=7.80) and (5) negated presence of schizophrenia or bipolar disorder. Participants were allocated to the schizophrenia group ($n=45$) if they: (1) affirmed the presence of schizophrenia/schizophrenia psychosis and (2) were diagnosed and treated for this disorder by a psychiatrist (e.g., neuroleptic medication, cognitive-behavioral intervention for schizophrenia). Repeated entries from the same computer were rejected by the software, and we also verified that none of the subjects shared the same combination of diagnosis, gender, age and level of education.

2.2. Questionnaire

At the end of the invitation, a web-link was presented giving access to a web-based questionnaire, which was implemented using OPST® software. On the introductory page, the study's rationale and scope was repeated. The entire survey took 20–30 min to complete.

2.3. Psychopathological assessment

The subsequent webpages contained questions about mental health: about whether the respondent had ever sought psychological treatment and, if so, when this occurred, the type of treatment received as well as the overall frequency of received treatments to date. Further, diagnoses determined during treatment were inquired (more than one diagnosis could be endorsed): depression, bipolar disorder, anxiety disorder, obsessive–compulsive disorder, post-traumatic stress disorder, schizophrenia, other (to be specified), or no psychiatric diagnosis at all. Participants were then asked about medication. Participants were also requested to indicate whether they have ever suffered from checking or washing compulsions. If affirmed, items 1–10 from the Yale–Brown Obsessive Compulsive Scale (Y-BOCS; Goodman et al., 1989) were administered to determine the overall severity of OCD symptoms. To avoid misunderstanding, the terms *obsessions* and *compulsions* were clearly defined and illustrated with examples beforehand. The validity of the German Y-BOCS self-report form has been previously asserted (Schaible et al., 2001).

Respondents then completed the Community Assessment of Psychic Experiences (CAPE; Stefanis et al., 2002), a 42 item measure of psychotic-related phenomena. Items are based on clinical rating scales but are worded in such a manner that the scale is appropriate for use in both healthy and clinical populations. This scale was followed by a probe question for psychosis indicating whether they have ever received treatment for a psychotic disorder or had particular (delusional) ideas. The mean of the weighted subscores before standardization were computed (see Konings et al., 2006).

2.4. Questions relating to normal thinking

A series of questions concerning normal thoughts were then given. Normal thoughts were defined as thoughts which the participant deliberately initiates or contemplates in his/her mind as "tools of rationality" (e.g., to select a meal on the menu, to think about how to respond to a particular question). Intrusions and obsessions fall outside this category and it was made clear that these would be assessed at a later stage.

To describe the *acoustic properties of the thoughts*, participants were asked to endorse whether their thoughts were a.) silent/cannot be heard at all, b.) like a quiet, whispering voice, c.) somewhat audible (i.e., the thought possesses certain acoustic properties, e.g., sounds rather male or female), d.) as loud as an external voice.

Then the degree of *controllability of thoughts* (autonomy) was examined: a.) fully controllable (I determine 100% on my own what and how I think), b.) predominantly controllable, c.) rarely controllable, d.) no control at all (my thoughts do what they want, I sometimes feel that I do not have any control over my thoughts). To describe whether thoughts seem alien, respondents endorsed one of the following a.) my thoughts fully correspond to my personality, b.) from time to time strange thoughts enter my mind, c.) sometimes my thoughts are really strange to me and somehow do not correspond to my personality or my beliefs and preoccupations, or d.) my thoughts do not correspond to my personality or to my beliefs and preoccupations, I have the impression that someone else is thinking them.

2.5. Questions relating to intrusive thoughts

Intrusions were defined as thoughts that are not like willed "tools of rationality" but rather thoughts that seem to arise out of the blue. They may be bothersome or sticky thoughts that one does not want to dwell on, such as obsessions (e.g., fears to contaminate another person, feeling guilty of causing an accident), catchy tunes and

strange thoughts that, for example, humiliate the person. They may, however, also contain creative ideas.

In addition to rating the acoustic, autonomous, and alien properties of intrusive thoughts (for response options see 2.4), *authenticity* was rated: How real are these intrusive thoughts and how do you react when they occur?: a.) I do not consider these thoughts as being real, b.) these thoughts exert a certain influence on me, c.) these thoughts influence me a lot, d.) these thoughts are so strong that at times I feel obliged to obey them. Then, the *degree of disturbance* was assessed: a.) these thoughts do not bother me at all, b.) these thoughts bother me at times, c.) I consider these thoughts as very bothersome, d.) these thoughts impair me a lot in my every-day life.

2.6. Questions relating to voice-hearing

The survey then automatically proceeded to the section about voice-hearing. Participants were asked if a voice has ever spoken to them (e.g., God, someone who has passed away, etc.) even though no one was present (voices from the TV, radio or telephone were explicitly excluded). An affirmative response triggered presentation of the four A's that describe hallucinations (acoustic, autonomous, alien, authentic) and the disturbance question. Subsequent questions assessed voice content (multiple response options could be endorsed): imperative, commenting, humiliating, confirming/positive, or other (to be specified).

Participants were then asked to report the degree to which "voice-hearing" differed from external voices in terms of : Loudness: a.) the perceived voice(s) or "inner voice" is/are as loud as real voices, b.) the perceived

voice(s) is/are louder than real voice(s), c.) the perceived voice(s) is/are quieter than real voice(s); Ego-Syntony: a.) the perceived voice(s) reflect(s) my inner thought(s), b.) the perceived voice(s) say(s) things, which I would never think of c.) the perceived voice(s) is/are as uncontrollable as external voices; and Reality: a.) the perceived voice(s) is/are not very real, b) the perceived voice(s) is/are almost as real as external voices, c.) the perceived voice(s) is/are not distinguishable from real voices. Participants then describe possible differences between "hearing voices" and real voices.

2.7. Hallucination-proneness

The survey proceeded with the 16-item version of the Launay–Slade Hallucination Scale (LSHS; Larøi and Van der Linden, 2005). The LSHS was supplemented with an additional item: "If you read a letter or an email from a close friend, do you hear his/her voice when reading it?" Principal components analysis (Larøi and Van der Linden, 2005) on the version of the LSHS used in the present study revealed a 5-factor structure: (1) sleep-related hallucinatory items, (2) vivid daydreams, (3) intrusive or vivid thoughts, (4) auditory hallucinations, and (5) visual hallucinations.

3. Results

3.1. Background characteristics

The groups did not differ on sociodemographic background characteristics (gender, age and school education, see Table 1). As expected, participants with

Table 1
Group differences on sociodemographic background characteristics and questionnaires (CAPE, LSHS)

Variable	Healthy	OCD	Schizophrenia	Statistics (post-hoc)
	($n=55$)	($n=60$)	($n=45$)	
Sociodemographic				
Age	35.60 (12.10)	32.70 (10.14)	35.18 (10.43)	$F(2,157)=1.17, p>.3$
Gender (M/F)	19/36	23/37	24/21	$\chi^2(2)=3.94, p>.1$
Years of school	12.62 (2.15)	12.28 (1.90)	12.11 (2.58)	$F(2,157)=0.71, p>.4$
CAPE (score (1–4)/items endorsed)				
Positive	1.34 (0.25)	1.44 (0.28)	2.13 (0.40)	$F(2,157)=93.18, p<.001; S>O, H$
Negative	1.81 (0.37)	2.21 (0.48)	2.39 (0.50)	$F(2,157)=27.71, p<.001; S>O>H$
Depression	1.80 (0.38)	2.42 (0.45)	2.36 (0.52)	$F(2,157)=33.58, p<.001; O, S>H$
LSHS				
Sleep-related	4.98 (1.28)	7.12 (2.31)	8.40 (2.30)	$F(2,146)=34.77, p<.001; S>O>H$
Daydreaming	3.46 (0.67)	3.58 (1.05)	4.47 (1.22)	$F(2,146)=13.75, p<.001; S>O, H$
Intrusive/vivid thoughts	3.85 (0.92)	3.91 (1.27)	4.90 (1.50)	$F(2,146)=10.08, p<.001; S>O, H$
Auditory hallucinations	3.92 (1.47)	3.89 (1.37)	5.62 (2.12)	$F(2,146)=16.13, p<.001; S>H, O$
Visual hallucinations	2.17 (0.55)	2.28 (0.62)	3.65 (1.49)	$F(2,146)=34.94, p<.001; S>O, H$

Notes. Means and standard deviations (in brackets); >=post-hoc difference at least $p<.05$ (Fisher's LSD).

schizophrenia reported a much higher rate of voice-hearing ($n=37$; 82%) than OCD patients ($n=9$; 15%) and healthy participants ($n=17$; 15%; $\chi^2(2)=68.19, p<.001$).

3.2. Questionnaires

As can be seen in Table 1, schizophrenic patients had significantly higher scores on the CAPE positive and negative factor, and the LSHS subscales, compared to both the healthy controls and the OCD group. For depression, both patient samples (OCD, schizophrenia) scored significantly higher than healthy controls. The CAPE and LSHS scores of the healthy subjects are largely comparable to recently published mean scores for epidemiological and non-clinical samples (Konings et al., 2006; Larøi & Van der Linden, 2005).

The validity of the procedure was supported by evidence that voice-hearing moderated differences on

Table 2
Differences between normal thoughts, intrusions and voice-hearing in terms of loudness (i.e., acoustic), control (i.e., autonomous), and conformity with personality (i.e., alien)

Loudness	Absolutely silent, cannot be heard (%)	Like a quiet whispering voice (%)	Somewhat audible (e.g., male/female) (%)	As loud as external voice (%)
Thoughts				
Healthy	80.0	7.3	10.9	1.8
OCD	68.3	10.0	13.3	8.3
Schizophrenia	60.6	13.8	18.1	7.5
Intrusions				
Healthy	78.2	9.1	9.1	3.6
OCD	61.7	8.3	21.7	8.3
Schizophrenia	24.4	20.0	44.4	11.1
Hallucinations (subgroup, $N=53$)				
Healthy	42.9	0	14.3	42.9
OCD	11.1	33.3	44.4	11.1
Schizophrenia	5.4	16.2	56.8	21.6

Control	Fully controllable (%)	Predominantly controllable (%)	Rarely controllable (%)	No control at all (%)
Thoughts				
Healthy	34.5	56.4	7.3	1.8
OCD	20.0	43.3	28.3	8.3
Schizophrenia	8.9	66.7	15.6	8.9
Intrusions				
Healthy	29.1	60.0	9.1	1.8
OCD	8.3	35.0	35.0	21.7
Schizophrenia	6.7	51.1	31.1	11.1
Subgroup hearing voices ($N=53$)				
Healthy	14.3	42.9	0	42.9
OCD	22.2	44.4	22.2	11.1
Schizophrenia	8.1	40.5	40.5	10.8

Conformity with personality and opinions	Thoughts fully correspond to my personality (%)	From time to time strange thoughts enter my mind (%)	Sometimes my thoughts are really strange to me (%)	It is like some else is thinking (%)
Thoughts				
Healthy	78.2	16.4	1.8	3.6
OCD	30.0	43.3	25.0	1.7
Schizophrenia	22.2	24.4	33.3	20.0
Intrusions				
Healthy	69.1	27.3	0	3.6
OCD	23.3	35.0	25.0	16.7
Schizophrenia	17.8	26.7	35.6	20.0
Hallucinations (subgroup, $N=53$)				
Healthy	28.6	28.6	0	42.9
OCD	37.5	25.0	25.0	12.5
Schizophrenia	10.8	32.4	37.8	18.9

Notes. Percentages may not add up to 100% due to rounding. Percentages in the rows relating to hallucinations only refer to the subgroup of voice-hearers and not the overall sample.

the hallucination proneness scale (LSHS): a MANOVA with Group (schizophrenia, OCD, healthy) and presence of Voice-Hearing (yes, no) as between-subject variables and LSHS subscale scores as dependent variables revealed main effects of Group (Wilk's Lambda = 4.29, $p < .001$) and Voice-Hearing (Wilk's Lambda = 5.37, $p < .001$), but no interaction (Wilk's Lambda = 1.20, $p > .2$). Post-hoc comparisons showed that voice-hearers had higher scores on all LSHS scales compared to non-voice-hearers (at least $p < .02$), irrespective of diagnostic status. OCD patients reporting hallucinations did not differ from OCD patients without hallucinations on the CAPE items tapping delusions and the insight item of the Y-BOCS ($p > .6$) confirming that these participants were not in fact schizophrenia patients with OCD (symptoms).

3.3. Thoughts, intrusions and voice-hearing

3.3.1. Acoustic properties

As can be derived from Table 2, 80% of the healthy participants confirmed that their normal thoughts were absolutely silent and inaudible, while only 68.3% of the OCD and 60.6% of the schizophrenia patients affirmed this. Conversely, 1.8%, 8.3% and 7.5% of the groups, respectively, reported their normal thoughts were as loud as an external voice. The model was significant, $\chi^2(6) = 32.85, p < .001$.

In the schizophrenia group, markedly few reported that their intrusive thoughts were silent. Among OCD patients, 38% reported that their intrusive thoughts were at least as loud as a quiet whisper. The model was again significant owing to higher rates of acoustic-like intrusive thoughts in both patient groups, $\chi^2(6) = 31.58, p < .001$. For voice-hearers, only a minority in each diagnostic group reported that it was as loud as an external voice.

3.3.2. Control

As can be derived from Table 2, a minority of participants indicated that their normal thoughts were fully controllable, $\chi^2(6) = 20.29, p = .002$. As expected, the overall degree of subjective control was lower for intrusions, particularly for OCD patients, $\chi^2(6) = 33.17, p < .001$: One-half to two-thirds of voice-hearers of each group acknowledged that they exerted a full or high degree of control.

3.3.3. Conformity with personality

Unlike healthy controls, less than one-third of OCD and schizophrenia participants reported that normal thoughts fully corresponded with their personality and

opinions, $\chi^2(6) = 57.05, p < .001$ (see Table 2). A similar picture emerged for intrusions. For both patient samples, a large subgroup affirmed that intrusions appeared as if someone else was thinking them, or that thoughts were somehow strange and "not them". This model was significant, $\chi^2(6) = 47.00, p < .001$. Conversely, a large proportion in each sample acknowledged that their voices were consistent with their personality and opinions.

3.3.4. Reality and degree of disturbance in everyday life

Most healthy participants described intrusions as mere thoughts, not taken as serious, while fewer OCD and schizophrenia patients shared this appraisal, $\chi^2(6) = 42.47, p < .001$ (Table 3). Similarly, most healthy participants did not experience intrusions as bothersome, while this was true for only a few patients, $\chi^2(6) = 65.13, p < .001$.

Healthy (28.6%) and OCD participants (37.5%) hearing voices, in particular, acknowledged that these voices were fallacies of the mind. A minority of each group (12.5–37.8%) reported that the voices would influence them greatly or that they have to obey them (none of the healthy and OCD participants affirmed the

Table 3
Differences between intrusions and voice-hearing in terms of reality and impairment (i.e., authentic quality)

Reality	Do not consider these as real (%)	Have certain influence on me (%)	Influence me a lot (%)	Very strong so that I at times feel obliged to obey them (%)
Intrusions				
Healthy	63.6	32.7	0	3.6
OCD	16.7	38.3	36.7	8.3
Schizophrenia	24.4	48.9	22.2	4.4
Subgroup hearing voices ($N = 53$)				
Healthy	28.6	57.1	14.3	0
OCD	37.5	50.0	12.5	0
Schizophrenia	18.9	43.2	35.1	2.7

Bothering	Not bothering at all (%)	Are sometimes bothering (%)	Very bothering (%)	Impair me a lot in my daily life (%)
Intrusions				
Healthy	63.6	29.1	3.6	3.6
OCD	8.3	26.7	46.7	18.3
Schizophrenia	17.8	40.0	17.8	24.4
Subgroup hearing voices ($N = 53$)				
Healthy	71.4	14.3	0	14.3
OCD	50.0	25.0	25.0	0
Schizophrenia	24.3	43.2	10.8	21.6

Notes. Percentages may not add up to 100% due to rounding.

latter category). Most responses in each group were observed for the response option: "voices have some influence on me". Regarding degree of disturbance in everyday life, 50% of the OCD and 71.4% of the healthy participants reported that the voices do not hinder them at all, relative to 24.3% of the schizophrenia participants.

3.3.5. Effects of diagnostic status

Ratings of thoughts, intrusions and hallucinations were subjected to a 3×2 ANOVA with Group (schizophrenia, OCD, healthy) and presence of Voice-Hearing as between-subject variables. Loudness of thoughts and intrusions both differed by Group (thoughts: $p = .03$; intrusions: $p = .02$) mirroring the effects described in section 3.3.1. In addition, the factor Voice-Hearing (thoughts: $p = .007$; intrusions: $p = .001$) but not the interaction yielded a significant effect (thoughts; $p > .5$; intrusions: $p > .1$). This indicates that voice-hearers, irrespective of diagnostic status, share enhanced acoustic imaginations at the stage of normal thoughts and intrusions. When voice-hearers were removed from the sample, 32% of the OCD patients and 19% of the healthy participants reported somewhat audible intrusions.

For items relating to control, the main effect of Group did not reach trend level ($p = .12$), and the main effect of Voice-Hearing and the interaction was clearly insignificant with respect to normal thoughts ($p > .5$). Mirroring the results from the one-way statistics, control of intrusions varied across Group ($p = .02$) but not Voice-Hearing ($p > .8$).

With respect to conformity with personality, the effect of Group was significant ($p = .001$) but the effect of Voice-Hearing ($p = .095$) and the interaction ($p > .5$) were not. A similar result emerged for conformity of intrusions (Group: $p < .001$; Voice-Hearing: $p > .4$; interaction: $p > .1$), and perceived reality of intrusions (no such question for normal thoughts; Group: $p = .004$; Voice-hearing: $p > .9$; interaction: $p > .3$). For the degree of impairment exerted by intrusions on everyday life, the main effect of Group was significant ($p < .001$) as well as the interaction ($p = .04$) but not the effect of Voice-Hearing ($p > .1$). Interestingly, the significant interaction revealed that healthy and schizophrenia voice-hearers were more disturbed by voice-hearing than by intrusions, whereas the opposite was true for OCD patients.

3.4. Additional questions on voice-hearing

Table 4 shows that a large number of voice-hearers acknowledged that the voices were not very real

Table 4
Characteristics of voices ($N=53$)

Reality of voices	Voices are not very real (%)	Voices are almost real (%)	Voices are not distinguishable from real voices (%)
Healthy	50.0	16.7	33.3
OCD	25.0	62.5	12.5
Schizophrenia	37.5	31.3	31.1
Conformity with personality and opinions	Voices reflect my inner thoughts (%)	Voices say things I would not think of (%)	Voices are as uncontrollable as external voices (%)
Healthy	66.7	16.7	16.7
OCD	50.0	25.0	25.0
Schizophrenia	15.6	40.6	43.8
Group/loudness	As loud as real voices (%)	Louder than real voices (%)	Less loud than real voices (%)
Healthy	66.7	0	33.3
OCD	62.5	12.5	25.0
Schizophrenia	31.3	6.3	62.5

(healthy: 50%, OCD: 25%, schizophrenia: 37.5%). These proportions exceed the proportions of participants that could not differentiate those voices from real voices. Interestingly, many more schizophrenia patients than OCD patients and healthy controls admitted that voices were quieter than real voices. Between one-half and two-thirds of non-psychotic participants reported that the voices mirror their own thinking relative to only 15.6% of the schizophrenia group.

4. Discussion

The major aim of the present study was to examine whether there is a distinct sensory and cognitive signature of voice-hearing relative to other mental phenomena. We were particularly interested in exploring the extent to which imagined voices are comparable to real voices according to the 4 A's (acoustic, alien, authentic, autonomous) and investigated whether scores on these four aspects would delineate a specific profile for voice-hearing, intrusions and normal thoughts.

4.1. Prevalence of voice-hearing

The present results corroborate with prior epidemiological findings showing that although auditory hallucinations are cardinal symptoms of psychosis, they cannot be equated with severe mental illness per se.

Indeed, as many as 15% of the healthy participants reported hearing voices, a rate similar to what other studies report (for a review see Johns, 2005; Johns and van Os, 2001). An identical rate was found in OCD patients, a population in which verbal hallucinations have not been systematically examined before (Hermesh et al., 2004, studied a circumscribed aspect of sensory irritations and found a prevalence of 41% of musical hallucinations in OCD patients). Among the schizophrenia patients, 82% acknowledged hearing voices which is broadly consistent with prior epidemiological findings (Wing et al., 1974).

4.2. Voice-hearing: more than a disorder of input

Challenging the view that voice-hearing solely arises from a disorder of input, only a minority reported that they are as loud as an external voice. Moreover, approximately every tenth voice-hearer acknowledged that these were inaudible. Only between 12.5% (OCD) and approximately one-third (healthy, schizophrenia) of the voice-hearers could not differentiate real from hallucinated voices and a large subgroup endorsed that they were unreal. This is in line with our claim that for some patients, hearing voices represents an inaccurate term to express that their cognitions are *not their own*.

In accordance with the claim that none of the 4 A's clearly set voice-hearing apart from other mental events, in particular intrusions, a large proportion of OCD patients reported that they exerted little or no control over the intrusions, found them alien, and acted upon them and/or took them seriously. A large proportion of OCD patients (40%) on the other hand acknowledged that the intrusions had perceptual qualities but concurrently did not characterize them as voices. Thus, differences among the three cognitive phenomena (thoughts, intrusions, voice-hearing) seem to be dimensional rather than categorical.

4.3. Cognitive mechanisms contributing to voice-hearing

We assert that a parsimonious explanation as to why a bothersome cognition is considered a self-generated intrusion or an external voice is, at least in part, based on liberal acceptance. We have previously maintained (Moritz et al., 2006a) that when a healthy person experiences a hallucination, careful appraisal of its characteristics gives rise to the attribution that the source must be one's own mind. In schizophrenia patients, on the other hand, a limited set of voice-like characteristics may suffice to mistake self-generated cognitions as real voices (e.g., content does not resemble normal thinking) while ignoring others (e.g., no overt source; Moritz et al., 2006a). In other words, patients with schizophrenia — unlike OCD and healthy participants — use less stringent criteria to test the source hypothesis. Metacognitive beliefs about the controllability of thoughts (Morrison et al., 1995) in conjunction with some acoustic properties and, for example, a feeling of endangerment may be sufficient for a participant to attribute self-generated input to another agent. This bias may be aggravated by a lack of "common sense" to generate alternative explanations (Freeman et al., 2004) or not using appropriate explanations such as Occam's razor heuristic (the easiest explanation is to be preferred). Indeed, the assumption of an external attack on the integrity of one's mind usually poses more questions than it provides answers! Another motif for a misattribution of agency apart from deficits in source monitoring (Woodward et al., 2007) could be a self-serving bias, which has been reportedly observed in schizophrenic patients (Bentall et al., 2001) and a gain from illness (Moritz et al., 2006b). That is, to infer that one suffers from voice-hearing may invoke a greater threat to the ego than the inference that one is persecuted by some alien force. The latter is less degrading, may not be infinite, and provides some voice-hearing patients with a sense of importance and company. Our observation that 78.1% of the schizophrenia patients reported positive hallucinatory content is consistent with this (reported elsewhere).

The influence of such top–down processes underlying voice-hearing may vary across participants. Interestingly, a large proportion of healthy voice-hearers claimed that the voices were loud. Nevertheless they were less disturbed by the voices and even considered them more unreal than schizophrenia patients presumably owing to more cognitive scrutiny. Interestingly, voice-hearers reported more vivid and audible thoughts and intrusions relative to those not hearing voices. It may be that such experiences reflect a predisposition to hearing voices. Although speculative at this point in time, we presume that, in healthy subjects hearing voices, vivid and perceptual imagination are the main constituents, that is, that the sensory signatures of thoughts and real auditory input are more similar. Consistent with this assumption, many healthy voice-hearers reported that their voices were as loud as real voices. Nevertheless, due to preserved reasoning processes, misattributions of source are infrequent and their impact is comparatively benign. In schizophrenia patients in turn, even less voice-like properties of mental events promote the sentiment of voice-hearing due to compromised common sense and distorted metacognitive beliefs.

4.4. Hallucinations and delusions

The present topic also bears relevance to our understanding of delusions. According to Maher (2006), delusions are not pathological as such but instead represent rational attempts to make sense of unusual perceptual experiences. Consistent with this view is the observation that delusions and hallucinations often co-exist and that neuroleptic administration usually improves hallucinations before it has an ameliorating impact on delusions (Gunduz-Bruce et al., 2005). However, problematic for this account is the fact that delusional beliefs can exist in the absence of hallucinations (Bell et al., 2006), and delusions in some cases precede the onset of hallucinations (Huschka, 2005). Further, out-of-the-world experiences are by no means uncommon in both healthy and especially neurological patients, but do not necessarily prompt a delusional explanation.

Our findings also challenge the view that delusions are a rational explanation for hallucinations. Such a view would predict higher scores on all of the 4 A's. Maher (2006) has inferred that a healthy participant who is confronted with the same mental phenomena or "out-of-the-world" experiences would arrive at the same inferences as a patient (hearing voices) which would bear similar consequences (delusional thinking). In our view, the same input that persuades a schizophrenic patient of being influenced by an outer voice may be judged different by most healthy subjects.

4.5. Limitations

Some limitations need to be acknowledged. Diagnoses relied on self-report data and were not externally verified. We have tried to compensate for this with a thorough verification process (data consistency, etc.) and by including a large sample that included a group of psychiatric controls. We think that several aspects add to the validity of the study. For example, patients with schizophrenia achieved higher scores on CAPE positive and negative symptoms than the psychiatric and healthy controls. Moreover, the CAPE positive mean score in the healthy population ($M = 1.34$) was comparable to that obtained in a normal, epidemiological population ($M = 1.4$) indicating that our healthy sample was representative (see Konings et al., 2006). Finally, in their recent article on the structure of paranoia, Freeman et al. (2005) conclude that "Internet research has been found to reach the same conclusions as laboratory-based studies" (p. 427), which is confirmed by many articles (Chinman et al., 2004).

Finally, as the survey was rather long (20–30 min) we think that it is unlikely that a subject would take such burden to mimic a false diagnostic status. A caveat with direct interviews is that although diagnoses can be readily confirmed, hallucinations are likely to be under-reported because of embarrassment, especially when having sexual content. It should also be noted that even structured clinical interviews depend on self-report by the patient.

4.6. Conclusion

To conclude, the present study highlights similarities between normal thoughts, intrusions and voice-hearing. Hallucinations are certainly experienced as more acoustic, alien, autonomous and authentic relative to other mental events. However, some of these properties also apply to intrusions and even to normal thoughts in non-psychotic participants. Consequently, differences are more quantitative than qualitative, which supports the view that voice-hearing is more than a disorder of input. The results do not completely refute a bottom–up account of voice-hearing but suggest the involvement of important top–down attributional processes. These top–down processes may vary across participants but most likely involve false metacognitive beliefs about the controllability of thoughts, liberal acceptance, gain from illness and self-serving biases. In our view, many subjects who hear voices have abnormalities with sensory inner perception which apparently arise already at the stage of thoughts and intrusions. Although this may act as a risk factor for hallucinations, it does not qualify as a mono-causal explanation. Indeed, most OCD patients that characterized their intrusions as alien, autonomous and somewhat acoustic did not attribute these to other (external) agents. Conversely, many voice-hearers acknowledged that their voices were either unreal, not very acoustic or under their (partial) control. The present findings suggest there is significant merit in the use of insight-based psychological interventions for schizophrenia (Garrett et al., 2006; Morrison, 2002; Valmaggia et al., 2005) and more specifically metacognitive training approaches (Moritz et al., 2007) that seek to modify hallucination-related misattributions by offering alternative explanations.

Contributors

Steffen Moritz designed the study. Frank Laroi managed the literature searches, some of the analyses and wrote parts of the manuscript. All authors contributed to and have approved the final manuscript.

Conflict of interest

Both authors declare that they have no conflicts of interest.

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