Schizophrenia Research 147 (2013) 301–309

Contents lists available at SciVerse ScienceDirect

Schizophrenia Research

journal homepage: www.elsevier.com/locate/schres

Failure of attention focus and cognitive control in schizophrenia patients with auditory verbal hallucinations: Evidence from dichotic listening

Kenneth Hugdahl [a,b,c,*], Merethe Nygård [a], Liv E. Falkenberg [a], Kristiina Kompus [a], René Westerhausen [a,b], Rune Kroken [b], Erik Johnsen [b,d], Else-Marie Løberg [a,b]

[a] Department of Biological and Medical Psychology, University of Bergen, Norway
[b] Division of Psychiatry, Haukeland University Hospital, Bergen, Norway
[c] Department of Radiology, Haukeland University Hospital, Bergen, Norway
[d] Department of Clinical Medicine, Section Psychiatry, University of Bergen, Norway

ARTICLE INFO

Article history:
Received 30 October 2012
Received in revised form 12 March 2013
Accepted 8 April 2013
Available online 9 May 2013

Keywords:
Auditory hallucinations
Schizophrenia
Dichotic listening
Attention
Executive function
Cognitive control

ABSTRACT

Auditory verbal hallucinations (AVHs) are speech perceptions that lack an external source, phenomenologically experienced as "hearing voices". A perceptual origin of an AVH experience in patients with schizophrenia can however not explain why the "voices" drain the attentional and cognitive capacity of the patients, making them unable to direct attention away from the "voices" and to cognitively suppress the experience. We recently reported how AVHs interfere with the perception of speech sounds, using a dichotic listening experimental paradigm. We now extend this finding by reporting on the interference caused by AVHs on attention and cognitive control, using a slight variation of the same dichotic listening paradigm. The patients ($N = 148$) were instructed to pay attention to and report from either the right or left ear syllable of the dichotic pair. We then correlated their PANSS score for the hallucination item (P3) with the performance score on the dichotic listening task. The results showed that AVHs interfered with the ability to report the *right* ear syllable when instructed to pay attention to the right side, which is a marker of inability to attend to an external speech stimulus. When instructed to pay attention to the left side, AVHs interfered with the ability to report the *left* ear syllable, which is a marker of inability to use cognitive control to suppress attending to the "voices". The corresponding correlations for the emotional withdrawal (N2) negative symptom were all non-significant. The correlations were substantiated in an ANOVA with corresponding significant group differences between high versus low symptom score groups. The results thus extend our previous findings of a perceptual origination for AVHs by showing that AVHs interfere with the ability to attend to the outer world around the patient, and the ability to inhibit, or suppress, the "voices" once they occur. Future research should pin down the neuronal basis of both the origination and the attentional and cognitive control aspects of AVHs.

1. Introduction

Auditory verbal hallucinations, AVHs, are the most typical single symptom in schizophrenia (Wing et al., 1974; David, 1999). AVHs could be seen as a "marker" of a psychotic episode (Wing et al., 1974; Shergill et al., 1998; Hugdahl et al., 2009), occurring in more than 70% of patients with a schizophrenia diagnosis. In addition to the symptomatic aspects of AVHs, hearing "voices" also has cognitive correlates, which add to the mental and social burden of the disorder. Hallucinating patients seem to focus on the "voices", i.e. they appear to have less ability to exhibit cognitive control of and disengage from the "voices" once they occur, and thus less ability to attend to events around them (Chadwick and Birchwood, 1994). In neuropsychological terms this could be phrased such that AVHs attract attentional focus (Posner and Driver, 1992) and impair the patient's cognitive control abilities (Lezak, 1994). From this follows that AVHs should interfere with processing of an external stimulus such that the more frequent the hallucinations, the less would a patient be able to attend to and cognitively control an external sensory stimulus. Alternatively, it could be argued that it is the negative content of the AVH typically experienced by patients with schizophrenia that causes a break-down of higher cognitive functions, or an interaction between the two factors. This effect should moreover be enhanced for a stimulus that shares qualities with an AVH, e.g. when the patient is required to process an external auditory speech sound (see also Hugdahl et al., 2009). Several functional magnetic resonance (fMRI) and positron emission tomography (PET) studies have shown a reduction in cortical blood flow and neuronal activation in prefrontal and parietal brain areas in

* Corresponding author at: Department of Biological and Medical Psychology, University of Bergen, Jonas Lies vei 91, N-5009 Bergen, Norway.
E-mail address: Hugdahl@psybp.uib.no (K. Hugdahl).

0920-9964/$ – see front matter
http://dx.doi.org/10.1016/j.schres.2013.04.005

patients with schizophrenia in situations demanding cognitive control and attentional focus (Weinberger et al., 1986; Pfefferbaum and Zipursky, 1991; Gur and Gur, 1995; O'Leary et al., 1996; Carter et al., 1998; Hugdahl et al., 2004). The functional imaging studies are supported by structural imaging studies that have shown reduced grey matter volume in several cortical areas in hallucinating patients, including frontal, parietal and temporal lobe areas (Neckelmann et al., 2006; Williams, 2008).

Although the imaging data lend support to the notion that brain areas involved in attention focus and cognitive control processes are affected in patients with AVHs, it alone does not reveal the origin of these effects. Hypothesis-driven behavior studies with directed predictions regarding the performance might be better suited to uncover the origin of these functional and structural brain changes. We would like to call the interference caused by AVHs for the processing of an external speech sound (cf. Hugdahl et al., 2012) the "voice interference", hypothesis which predicts that (a) AVHs should interfere with *attention and cognitive control* demands associated with an external stimulus, (b) the interference should be stronger in patients the more frequently they experience AVHs. Moreover, as also mentioned above, the interference should be particularly strong for a stimulus presented within the same sensory modality, like an acoustically presented speech sound. Thus, we considered the so called "forced-attention" dichotic listening paradigm (see Hugdahl and Andersson, l986, see also Bryden et al., 1983) a possible paradigm for testing the voice interference hypothesis. The "forced-attention" paradigm makes it possible to study ability for attention focus and cognitive control in the same experimental set-up (cf. Løberg et al., 1999; Gadea et al., 2000; Hugdahl et al., 2009; Bouma and Gootjes, 2011; Falkenberg et al., 2011). This would be an advantage when testing patients with severe disorders since the task is simple to perform, and the overall processing demands and task difficulty do not vary for the different conditions, something that frequently confounds classic neuropsychological studies where overall difficulty of the tests used often varies.

The "forced-attention" paradigm has been applied to numerous non-clinical and clinical groups (Løberg et al., 1999: Hugdahl, 2003; Gootjes et al., 2006; Løberg et al., 2006; Hugdahl et al., 2009; Pollmann, 2010; Bouma and Gootjes, 2011; Falkenberg et al., 2011; Hiscock and Kinsbourne, 2011; Kompus et al., 2011, 2012; Carlsson et al., 1994). We therefore here present an abbreviated version of the logic behind the paradigm. In the standard variant of the consonant-vowel (CV)-syllables dichotic listening paradigm, with no explicit instruction for attention focus or need for executive control, subjects report more correct items from the right ear compared to the left ear syllable of the dichotic pair on each trial. This is due to two factors, the preponderance of the contralateral auditory pathways (Rosenzweig, 1951; Kimura, 1967; Pollmann et al., 2002; Brancucci et al., 2004), and the superior processing ability of the left hemisphere (temporal lobe) for speech sounds (Kimura, 1967; van den Noort et al., 2008). The result is called a Right Ear Advantage (REA) (Shankweiler and Studdert-Kennedy, 1967; Bryden, 1988). By explicitly instructing the subject to focus attention on and report only from the right ear (originally labeled "forced-right" (FR) attention by Hugdahl and Andersson, l986), the REA is increased due to the synergistic action of the bottom-up, perceptual REA together with the top-down, cognitively demanding focus of attention on the right ear stimulus. In other words, the REA is increased because the bottom-up REA is aided by attention focus on the same side. The opposite situation, when the subject is explicitly instructed to focus attention on and report only from the left ear, is however fundamentally different from the FR situation. In this latter situation the bottom-up and top-down systems act antagonistically, and the result is a cognitive conflict (cf. Braver et al., 2002; Hugdahl et al., 2009; Westerhausen et al., 2010; Falkenberg et al., 2011) which is in need of cognitive control to be resolved. This situation was labeled "forced-left" (FL) attention by Hugdahl and Andersson (l986), and would require the inhibition of a strong response tendency (to report the right ear stimulus), in addition to use top-down cognitive control to instead report the weaker stimulus element of the dichotic pair (the left ear stimulus). This would be in line with the sub-components of inhibition and shifting in the terminology used by Miyake et al. (2000). Thus, the FR and FL instruction conditions allow for the study of attention focus and cognitive control with the same experimental paradigm, where stimulus parameters stay constant between conditions.

We now suggest that the "forced-attention" dichotic listening paradigm as it is described above would be ideal for a study of attention focus and cognitive control interference caused by AVHs. The specific predictions were that AVHs should cause interference with processing of the *right ear* signal in the FR instruction condition, and with the *left ear* signal in the FL instruction condition. Thus, there should be a significant negative correlation between scores on the Positive and Negative Syndrome Scale (PANSS) (Kay et al., 1987) hallucination (P3) item and number of correct reports for the *right* ear syllable in the FR instruction condition, and a corresponding significant negative correlation between the hallucination item score and correct reports for the *left* ear syllable in the FL instruction condition. Non-significant correlations were predicted for the left ear syllable in the FR condition, and for the right ear syllable in the FL condition, respectively. We selected the emotional withdrawal (N2) item as a control condition (cf. Hugdahl et al., 2012) where non-significant correlations were predicted for both the left and right ear syllables, and for both the FR and FL instruction conditions. We also correlated the left and right ear dichotic listening scores with the sum total of the PANSS positive and negative symptom scores as a measure of overall load on positive and negative symptoms.

2. Method

2.1. Subjects

The subjects were 148 patients with a DSM-IV or ICD-10 diagnosis of schizophrenia. The patients were the same as the 160 participants who participated in the Hugdahl et al. (2012) study minus the 12 Turkish patients, where data on the FR and FL conditions were missing, thus, the total sample was 148. The data were collected from two sub-samples, from two different countries, Norway (n = 120), USA (n = 28).[1] The differences in sample size precluded however any meaningful statistical comparison between the sub-samples, the trend of the findings was however similar at both sites. The subjects in the Norway sample were interviewed for symptom severity using the PANSS. The USA sample underwent the Brief Psychiatric Rating Scale (BPRS) interview (Ventura et al., 1993), in which case the scores were converted to PANSS scores, since these scales are positively correlated (Nicholson et al., 1995). Patients were on medication, with either typical or atypical antipsychotic medication. The patients' age was between 18 and 73 years, and with 108 males and 40 females in the sample (a separate analysis on the 40 females showed that the direction of the correlations was similar as for the entire sample). The distribution of the 148 patients across the range of PANSS scores for the P3 and N2 symptoms is seen in Table 1.

2.2. The dichotic listening task

The task used was the same as in the Hugdahl et al. (2012) study (with the modification of the "forced-instruction" conditions). In

[1] Dichotic listening data from some of these patients have previously been published in Løberg et al. (1999) and Hugdahl et al. (2003, 2008), but in a different context and with different analyses. All data have been re-analyzed for the present study.