



Current perspectives on the mechanisms of auditory hallucinations: introduction to the special research topic

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Edited by:

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Keywords: auditory hallucinations, cognition, emotion, hearing voices, non-clinical hallucinations, psychosis, schizophrenia

According to the Oxford English Dictionary (<http://www.oed.com>) the term “perspective” is derived from the verb *perspicere* (from *per-* “through” + *specere* “to look”), meaning “looked at closely.” In keeping with this origin, the contributors to this Frontiers Research Topic have indeed *looked closely* at the experience of auditory hallucinations (AH), providing new insights into the precise nature of hallucinations in clinical and non-clinical groups; the underlying cognitive, emotional and neural processes; and how this evidence might inform the next generation of personalized treatments Connor and Birchwood (2013).

The phenomenology of AH and the mechanisms that underpin them lie at the heart of our research, yet there has been a growing concern that the characteristics of AH prioritized by researchers don't match those considered important to hallucinators themselves. To some degree this disparity reflects the (sometimes) limited scope of popular research assessment tools. However, disregarding the phenomenological diversity of AH may guarantee that we will fail to understand the biopsychosocial processes involved. Consequently, the resurgence of interest in phenomenological research reflected in current contributions is both timely and welcome. McCarthy-Jones et al. (2013) call for more nuanced descriptions of AH that reflect more accurately what the experience is like, and proffer a philosophical phenomenological perspective, which encourages a systematic exploration of (normal and AH) experiences from the first person perspective. Both Badcock and Chhabra (2013) and deLeede-Smith and Barkus (2013) tackle the diverse presentations of AH in clinical and non-clinical groups. deLeede-Smith and Barkus adopt a developmental perspective, charting how the features of AH emerge and persist across the lifespan, and suggest that mechanisms maintaining AH differ across these populations, whilst Badcock and Chhabra (2013) provide an extensive and reflective review of the literature on the perception of voice identity, which points to subtle biases across different levels of voice identity. Rounding out this set of articles, Stephane (2013) emphasizes the heterogeneity of AH from one voice hearer to the next, and persuasively argues that whilst hallucinatory experiences are unique to each individual they are not random collections of features. Instead, Stephane suggests, they arise from a limited number of dimensions of phenomenological AH space—each linked to a separate neural basis.

Continuing the neural processing theme, Kompus et al. (2013) show that while non-clinical voice hearers present with a reduced response to speech sounds in the primary auditory cortex, attentional modulation of this area is intact. In strong contrast, no attentional modulation of this area could be observed in schizophrenia patients with AH. Further similarities as well as differences in mechanisms underlying AH are shown by Dahoun et al. (2013) who compared neural correlates of mentally simulated actions (e.g., “open a window”) between hallucination-prone adolescents and a group with a genetic risk for schizophrenia (22q11.2 deletion syndrome). While both groups exhibited decreased activation in regions related to self-other distinction when imagining a close friend performing an action, individuals with a genetic risk for schizophrenia displayed additional decreased activations in areas associated with visual imagery, episodic memory and social cognition when “simply” seeing a cue that said either “you” or “best friend” earlier on in the task.

Another set of articles highlight the role of emotion in AH. Kanemoto et al. (2013) show that university students with high hallucination proneness tended to make more external misattributions of inner thoughts than those with lower hallucinations proneness. Importantly, they also show that emotional valence affected the ability to recall whether a word had been previously heard, or had been imagined, only in the latter group of subjects. Similarly, with the help of an implicit emotional prosody task, Alba-Ferrara et al. (2013) examine how attention is involuntarily captured in patients with schizophrenia and healthy controls, and conclude that patients with AH may be less lateralized in their processing of emotion conveyed in voice. Finally, based on studies that have demonstrated that patients with schizophrenia have difficulty perceiving and discriminating emotions based on affective prosody compared to healthy controls, Tucker et al. (2013) wished to examine whether this may also represent an endophenotype of schizophrenia, i.e., by examining this capacity in non-affected, first-degree relatives. They found that unaffected relatives of AH schizophrenia patients, compared to the matched healthy controls, exhibited some basic impairments in auditory processing, suggesting that auditory processing deficits may be a core feature of AH in schizophrenia, but that the two groups did not differ significantly on a major variable, i.e., number of errors in pitch discrimination. Clearly, more research is needed in

order to examine whether these difficulties represent a potential endophenotype for AH.

Finally, from a neurofunctional perspective, two papers report new findings in patients with schizophrenia and auditory verbal hallucinations (AVH). Homan et al. (2013) used Arterial Spin labeling (ASL)—a Magnetic Resonance technique for measuring cerebral blood flow (CBF)—to show that increased perfusion in the left superior temporal gyrus (STG; a cerebral area known to support language and auditory function) in patients with schizophrenia and AVH, relative to controls and global CBF in patients, was not reduced by treatment with transcranial magnetic stimulation even though AVH symptom scores decreased over the treatment period. These findings are consistent with what has previously been termed a trait marker of AVH in schizophrenia. The second paper by Koeda et al. (2013) used a novel functional MRI favorability judgment task to show that hypo-activation in the left STG may be associated with brain dysfunction in accessing vocal attractiveness in schizophrenia, although right fronto-parietal regions could offset STG dysfunction associated with social communication.

In sum, the variety of perspectives featured in this Research Topic illustrates the vitality of current research on AH across a range of diagnostic groups, and the significant advances that have been made in understanding the mechanisms that underlie them.

REFERENCES

- Alba-Ferrara, L., de Erausquin, G. A., Hirnstein, M., Weis, S., and Hausmann, M. (2013). Emotional prosody modulates attention in schizophrenia patients with hallucinations. *Front. Hum. Neurosci.* 7:59. doi: 10.3389/fnhum.2013.00059
- Badcock, J. C., and Chhabra, S. (2013). Voices to reckon with: perceptions of voice identity in clinical and non-clinical voice hearers. *Front. Hum. Neurosci.* 7:114. doi: 10.3389/fnhum.2013.00114
- Connor, C., and Birchwood, M. (2013). Through the looking glass: self-reassuring meta-cognitive capacity and its relationship with the thematic content of voices. *Front. Hum. Neurosci.* 7:213. doi: 10.3389/fnhum.2013.00213
- Dahoun, T., Eliez, S., Chen, F., Badoud, D., Schneider, M., Larøi, F., et al. (2013). Action simulation in hallucination-prone adolescents. *Front. Hum. Neurosci.* 7:329. doi: 10.3389/fnhum.2013.00329
- deLeede-Smith, S., and Barkus, E. (2013). A comprehensive review of auditory verbal hallucinations: lifetime prevalence, correlates and mechanisms in healthy and clinical individuals. *Front. Hum. Neurosci.* 7:367. doi: 10.3389/fnhum.2013.00367
- Homan, P., Kindler, J., Hauf, M., Walther, S., Hubl, D., and Dierks, T. (2013). Repeated measurements of cerebral blood flow in the left superior temporal gyrus reveal tonic hyperactivity in patients with auditory verbal hallucinations: a possible trait marker. *Front. Hum. Neurosci.* 7:304. doi: 10.3389/fnhum.2013.00304
- Kanemoto, M., Asai, T., Sugimori, E., and Tanno, Y. (2013). External misattribution of internal thoughts and proneness to auditory hallucinations: the effect of emotional valence in the Deese–Roediger–McDermott paradigm. *Front. Hum. Neurosci.* 7:351. doi: 10.3389/fnhum.2013.00351
- Koeda, M., Takahashi, H., Matsuura, M., Asai, K., and Okubo, Y. (2013). Cerebral responses to vocal attractiveness and auditory hallucinations in schizophrenia: a functional MRI study. *Front. Hum. Neurosci.* 7:221. doi: 10.3389/fnhum.2013.00221
- Kompus, K., Falkenberg, L. E., Bless, J. J., Johnsen, E., Kroken, R. A., Kråkvik, B., et al. (2013). The role of the primary auditory cortex in the neural mechanism of auditory verbal hallucinations. *Front. Hum. Neurosci.* 7:144. doi: 10.3389/fnhum.2013.00144
- McCarthy-Jones, S., Krueger, J., Larøi, F., Broome, M., and Fernyhough, C. (2013). Stop, look, listen: the need for philosophical phenomenological perspectives on auditory verbal hallucinations. *Front. Hum. Neurosci.* 7:127. doi: 10.3389/fnhum.2013.00127
- Stephane, M. (2013). Auditory verbal hallucinations result from combinatoric associations of multiple neural events. *Front. Hum. Neurosci.* 7:239. doi: 10.3389/fnhum.2013.00239
- Tucker, R., Farhall, J., Thomas, N., Groot, C., and Rossell, S. L. (2013). An examination of auditory processing and affective prosody in relatives of patients with auditory hallucinations. *Front. Hum. Neurosci.* 7:531. doi: 10.3389/fnhum.2013.00531

Received: 12 October 2013; accepted: 30 October 2013; published online: 18 November 2013.

Citation: Badcock JC, Larøi F, Diederens K and Allen P (2013) Current perspectives on the mechanisms of auditory hallucinations: introduction to the special research topic. *Front. Hum. Neurosci.* 7:792. doi: 10.3389/fnhum.2013.00792

This article was submitted to the journal *Frontiers in Human Neuroscience*.

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