
Flavie Waters1,2,*, André Aleman3, Charles Fernyhough4, and Paul Allen5

1Centre for Clinical Research in Neuropsychiatry, Graylands Hospital, Mail Bag No 1, Claremont, Perth 6910, Western Australia; 2School of Psychiatry and Clinical Neurosciences, The University of Western Australia, Perth, Western Australia; 3BCN Research School, University Medical Center Groningen, Groningen, The Netherlands; 4Department of Psychology, Durham University, Durham, UK; 5Psychosis Studies Department, Institute of Psychiatry, King’s College London, London, UK

*To whom correspondence should be addressed; tel: +61-8-9347-6429, fax: +61-8-9384-5128, e-mail: Flavie.Waters@health.wa.gov.au

This article presents a report on the first meeting of the International Consortium on Hallucination Research, which took place on September 13–14, 2011 at the Institute of Psychiatry, London. The first day of the meeting served to reflect on the current state of knowledge regarding auditory hallucinations in different diagnostic groups, based on the presentations from the phenomenology, cognition, emotion, electrophysiology, neurochemical, neuroimaging, genetics, treatment, and computational modeling working groups. The second day comprised a discussion forum where the most important and urgent questions for future research were identified. The meeting recognized that a lot has been achieved in auditory hallucination research but that much still remains to be done. Here, we outline the top 16 goals for research on auditory hallucinations, which cover topics of conceptual importance, academic and treatment issues, scientific rigor, and cross-disciplinary collaboration. Concerted and coordinated actions will be required to make substantial research progress.

Key words: auditory hallucinations/meeting/phenomenology/cognition/electrophysiology/neuroimaging/treatment

Introduction

This meeting report summarizes the proceedings of the first meeting of the International Consortium on Hallucination Research held September 13–14, 2011, at the Institute of Psychiatry (IoP), London, UK. This inaugural meeting served to critically evaluate the present state of knowledge and methodological issues regarding auditory hallucination research and to provide a platform for researchers to meet and collaborate on projects relating to hallucinations in clinical and nonclinical populations. The meeting also aimed to energize research into auditory hallucinations, promote scientific rigor, and develop a consensus-based approach regarding the substance and direction of research and clinical approaches for treatment. Forty-four clinicians and researchers from Australia, Belgium, Canada, France, Italy, Germany, the Netherlands, Spain, Switzerland, the UK, and the USA attended the meeting. Ahead of the meeting, 7 working groups (comprising 51 international contributors) were formed, whose objectives were to prepare a comprehensive summative report and present at the meeting the most salient findings and recommendations for future research and/or treatment. The first day saw 8 presentations limited to 20 minutes each, followed by an open discussion on the topic. The second day comprised a “discussion forum,” where the main priorities, direction, and content for future research were discussed. This cross-fertilization of ideas and interdisciplinary discussions across the 2 days will hopefully be of broad benefit, by promoting high-quality research with translation opportunities for clinical work. Our website (hallucinationconsortium.org) summarizes the goals of the Consortium, the program of the meeting, the composition of working parties, and contributors to the workshop discussions. The work group summative reports, as presented at the meeting, will be published in a special theme of Schizophrenia Bulletin (July 2012).

Working Group Reports, September 13, 2011

The first day of the meeting started with a welcome note by the organizer of the meeting, Flavie Waters, with brief introduction of the goals and objectives of the meeting. She also thanked Paul Allen for hosting and helping to organize the meeting at the IoP. This was followed by
an opening address by Anthony David, who provided a historical overview of hallucination research in schizophrenia and outlined the significance of such progress. David also described the key features of "voices" that are proving particularly difficult to explained, such as the perception of externality (ie, nonself origin), affective contents, and intermittent nature of hallucinations.

The morning session comprised presentations from the phenomenology, cognition, emotion, and electrophysiology working groups. The first speaker, Frank Larøi (representing the phenomenology work group), compared and contrasted the phenomenological features of auditory hallucinations in schizophrenia, prepsychotic states, bipolar disorder, nonclinical individuals, and individuals with Parkinson’s Disease, epilepsy, substance abuse, borderline personality disorder, dementia, and eating disorders. While studies show that auditory hallucinations are a common experience in some of these conditions, more studies are needed describing their phenomenological characteristics. Larøi concluded by stating that agreed-upon definitions and taxonomies of phenomenological components and the development of standardized scales designed to assess hallucinations across clinical groups should remain high on the list of priorities.

Flavie Waters (representing the cognitive sciences work group) examined ways in which cognitive findings and methodological tools drawn from schizophrenia research may be applied to transdiagnostic investigations of auditory hallucinations. She examined the strengths and limitations of tasks employed in schizophrenia research and reflected that, in the future, great care must be taken to ensure that experimental tasks have high construct validity and that they reflect the state-of-the-art in cognitive neuroscience. Waters also highlighted the need for more hallucination research in different clinical and nonclinical (eg, nonschizophrenia) populations so that similarities and differences between groups may be outlined. She concluded that investigations must be tailored to the types of hallucinations, which differ between diagnostic groups (ie, investigations must be “feature based”). In other words, different phenomenological dimensions (for example, verbal vs nonverbal hallucinations) may have different underlying mechanisms and should be adequately considered, and characterized, in studies of the phenomena.

André Aleman outlined research on emotional precedents and concomitants of hallucinations. For example, levels of distress may rise before the occurrence of hallucinations. The involvement of emotional brain systems (eg, amygdala circuits) has also been implicated by some functional magnetic resonance imaging (fMRI) studies. He proposed that heightened levels of subcortical dopamine transmission may enhance priming of sensory cortex by the amygdala. In conclusion, overactivation of emotion processing in the right hemisphere, in combination with reduced connectivity to the left hemisphere language system, may also play a role but deserves more detailed investigation. Richard Bentall presented evidence to suggest that trauma in early life causes an increased risk of psychosis in adulthood, prompting questions about mechanisms of action regarding the role of trauma on the cognitive and emotional mechanisms implicated in hallucinations. He outlined recent findings that addressed this issue. In an experience sampling study, the onset of hallucinations was preceded by reports of transitory dissociative experiences. In the second report, patients with hallucinations were compared with healthy controls on measures of childhood sexual abuse, dissociation, and source monitoring. Source monitoring abnormalities were detected in both currently and remitted hallucinators and appeared to be a trait vulnerability factor for hallucinations; however, source monitoring performance was not related to dissociation. Dissociation scores were highest in patients who were currently hallucinating and mediated between childhood trauma and a trait measure of hallucination proneness. Bentall concluded that the evidence seemed to support a 2-hit model with source monitoring as a vulnerability factor and emotional disturbance consequent on trauma triggering hallucinations.

Judith Ford (representing the electrophysiology working group) described the state-of-the-art electrophysiological tools that have been employed to assess both the phenomenon of auditory hallucinations and the neural mechanisms by which they occur. She described 3 types of studies done using electroencephalography (EEG) and magnetoencephalography (MEG): symptom capture studies during the hallucinatory state, trait studies comparing people who hallucinate and people who do not, and mechanistic studies. There are 2 types of state studies: in 1 type, brain activity during periods of hallucinations is compared with periods without hallucinations and in the other, auditory cortical responsiveness is probed during those states using external sounds. Both types of state studies confirm functional MRI data suggesting that auditory cortex is involved in the experience of hallucinations. Trait studies confirm that the auditory cortex is less responsive to external sounds in people who tend to hallucinate, suggesting that the auditory processing bandwidth is biased to process internal dialog at the expense of external sounds. Mechanistic studies have focused on deficits in self-monitoring of internal experiences. Ford concluded that (1) all neurophysiological studies would benefit from better clinical assessment of the phenomena and (2) human neurophysiology lends itself to translational studies because of the overlap of methods between clinical and bench neuroscience.

The afternoon session comprised presentations on the neurobiology, neuroimaging, genetics, and treatment of auditory hallucinations.

Paul Shotbolt outlined neurochemical-imaging studies in auditory hallucinations. Neurochemical images from positron emission tomography (PET) and single photon
F. Waters et al.

...is capable of reducing the frequency and severity of auditory hallucinations in some individuals. Several meta-analyses found significantly better symptom reduction for low-frequency rTMS as compared with placebo. As a consequence, TMS currently has the status of a potentially useful treatment method for auditory hallucinations but only in combination with antipsychotic treatment. It is important to note that some recent trials failed to find a beneficial effect of rTMS over placebo. On the other hand, several parameters deserve to be further studied, e.g., high frequency rTMS.

Paul Allen outlined neuroimaging studies in patients with auditory hallucinations. The findings were presented from structural, functional (activation and cognitive studies), Diffusion Tensor Imaging, functional and effective connectivity, gyrification, and spectroscopy studies. Although there is currently insufficient neuroimaging evidence to fully understand the neurobiological substrate of auditory hallucinations, they are characterized by reduced gray matter volumes in the temporal cortex (middle and superior temporal gyrus, of functional significance for language networks) and altered functional activation in the auditory, prefrontal and cingulate cortex, supplementary motor area, hippocampus, and cerebellum (all areas thought to be involved in monitoring processes and/or self-referential processes). Altered frontotemporal connectivity, gyriﬁcation and decreased glutamate, and neuronal integrity in the hippocampus and thalamus have been also been reported in patients with auditory hallucinations. It was concluded that factors such as small sample sizes, state-trait confounds, poor construct validity of cognitive paradigms, symptom specificity, and medication confounds have interfered with progress.

Julio Sanjuan (in the genetics working group) spoke about auditory hallucinations as a possible phenotype. He considered the arguments and advantages supporting the examination of hallucinations as a possible phenotype, mainly that they are (1) a hallmark of psychosis, (2) easily identified, and (3) most likely to be captured when compared to other features of psychosis. Putative animal models of hallucinations also exist, suggesting that phenotypic variance may be investigated in other model organisms. Different genotypes might code different proneness to hallucinations by inducing variances in the threshold of sensory gating. Also outlined were evidence of neurologic disease that have auditory hallucinations, genetic studies of hallucinations in psychosis, and models of genetics. Sanjuan concluded by presenting a genetic-endophenotype-phenomenological model of auditory hallucinations that considered the role of environmental interactions.

Karin Slotema and Iris Sommer (in the treatment group) outlined the results of transcranial magnetic stimulation studies (TMS), and how repetitive TMS (rTMS) is capable of reducing the frequency and severity of hallucination experiences linked to schizophrenia groups, although it does not appear to underlie the experience of hallucinations in nonclinical population groups. More studies of DA release are needed, although caution is advised in medicated patients whose dopaminergic and anticholinergic medications may confound the results.

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Renaud Jardri and Sophie Deneve described how a computational framework can explain some of the complexity of large brain-like networks by predicting how basic changes in neural architecture may lead to systems-level changes that translate in turn to changes in behavior. Indeed, computational models offer ways to unify basic neurochemical findings with more macroscopic levels and start to be applied to cognitive sciences and psychiatry. Some of these approaches are aimed at teasing out the underlying mechanisms of subjective experiences, such as hallucinations, which can spontaneously emerge into consciousness in the absence of any corresponding external stimuli. Four main framework categories were proposed: disconnectivity, neurodynamic, noise, and bayesian models of hallucinations. Finally, Jardri and Deneve presented recent results from simulation of these neural networks and explained how potential alterations may lead to aberrant experiences.

Discussion Forum, September 14, 2011

The primary aim of day 2 was to provide an opportunity for researchers to discuss methodological and academic issues in a manner that would enhance the standards of scientific work on hallucinations and increase international efforts to work together and speak as one united voice. After listening to the working group summative reports on day 1, the attendees identified the most important and urgent questions to be addressed. The format of day 2 was a discussion forum, with people working initially in small groups, followed by a general discussion. The atmosphere of the discussions was substantially collegial, open, and collaborative.

Table 1 outlines the top 16 goals, or “grand challenges,” as identified in discussions. Conceptual issues surrounding our understanding of mental experiences, inner speech, thoughts, as well as monitoring and misattributions were extensively discussed, and the need for integrative discussions and debates incorporating linguistics, philosophy, cognitive sciences, neuroimaging, and electrophysiological perspectives was discussed. There was also a consensus that basic and clinical research on hallucinations needs to be better informed by phenomenology and that our understanding of phenomenological parameters in different clinical and
Table 1. Top 16 Goals in Auditory Hallucinations Research

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<th>Broad Topic</th>
<th>Challenges and Goals*</th>
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| Conceptual issues | 1. Outline what is so special about auditory hallucinations by placing hallucination research within a context of an examination of typical mental experiences, inner speech, intentionality, unbidden thoughts, and cognitive intrusions and by adopting perspectives from linguistics, philosophy, cognitive sciences, neuroimaging, and electrophysiological research.  
2. Enhance understanding of conceptual issues surrounding source-monitoring, self-monitoring, internal vs external misattributions, and “misperceptions” of internal and external events. |
| | 3. Improve our understanding of:  
   (1) The phenomenology of auditory hallucinations in different clinical and non-clinical groups,  
   (2) Phenomenological changes that occur before hallucinations are clearly developed (eg, in prodromal phases),  
   (3) The dynamic quality of phenomenological characteristics of auditory hallucinations (ie, characteristics that change as function of clinical state, interventions, etc). |
| | 4. Develop a taxonomy that can be utilized to compare and contrast hallucinations across diagnostic groups and design/validate a new hallucination assessment scale that can be applied to different diagnostic groups.  
5. Validate phenomenological features against biological, cognitive, and imaging correlates (linking brain networks and brain systems with phenomenological features). |
| Cognitive, neurobiological, and general scientific | 6. Understand the contribution of social, affective, and environmental factors in the etiology, maintenance, and trigger of auditory hallucinations.  
7. Increase the identification and characterization of biomarkers (genetic, electrophysiologic, neurotransmitters, etc). Also identify state and trait factors and those factors responsible for the onset, and maintenance of hallucination, and pursue a better understanding of protective and resilience factors.  
8. Conduct comparative research of the mechanisms underlying hallucinations across different modalities (auditory, verbal, somatic, etc), and in different clinical and nonclinical groups, and tailor studies to test mechanisms underlying different types of hallucinations. |
| Treatment issues | 9. Select cognitive domains, brain networks, and phenomenological features as a target for translational research and improve our understanding concerning how various phenomenological characteristics of hallucinations are modified after treatment.  
10. Identify differences and similarities in treatment needs, and burden, from auditory hallucinations in clinical and nonclinical populations.  
11. Use up-to-date knowledge on the neurobiology of hallucinations to create new focal treatments to diminish hallucinations in medication resistant patients. |
| Ensuring high-quality procedures and protocols | 12. Make recommendations for grouping patients in hallucination research, irrespective of diagnosis. Similarly, an index scale reporting on the temporal recency and severity of hallucinations should be designed, and then used in studies of hallucinations so that conclusions maybe made regarding the comparability of findings across studies.  
13. Improve on the quality of reporting in scientific articles on the characteristics of participants’ hallucinations and clinical profile.  
14. Promote the use of behavioral and experimental tasks that have high construct validity and strong psychometric properties. They must represent state-of-the art in cognitive neuroscience and must be able to discriminate between hallucination and other symptoms. These tasks could also be applied in EEG and MRI research. |
| Enhancing cross-disciplinary work and international collaboration | 15. Reconcile research findings, and identify gaps, between different research disciplines. For example, an integrative review of perspectives from philosophy, cognitive sciences, and electrophysiological approach may yield novel theoretical ideas that would help to “fine-tune” concepts used to describe hallucinations and their characteristics. The development of computational models with predictions for cognitive and neuroimaging research will also enhance the mechanistic understanding of genesis and maintenance of hallucinations.  
16. Establish a collaborative platform to make research and clinical trials more effective, reduce inefficiencies in research, and increase sample size. This may be established with the following:  
(1) Drawing a contact list of individuals being interested in collaborating in hallucination research,  
(2) Conducting between-center studies with international groups with a common interest in hallucinations,  
(3) Standardizing symptom assessments and data acquisition protocols to allow multi-site international studies, and  
(4) Pooling data between different centers (neuroimaging data, phenomenology data, etc) to maximum research outcomes of data already collected. |

Note: EEG, electroencephalography.  
*This ordering of points does not denote a priority of importance.
nonclinical groups must improve. Better characteriza-
tion of hallucinations and improved reporting on hallu-
cination dimensions would also allow us to constrain
our thinking and focus in neural/cognitive research.
In addition, the need for a hallucination assessment
scale that can be applied to different diagnostic groups
was also discussed in view of increasing work in popu-
lations other than schizophrenia. Several academic
issues ranging across cognitive, electrophysiological,
neuroimaging, and genetic viewpoints were also raised,
which centered around the need to extend the knowledge
base, and develop novel ideas, on the mechanisms re-
sponsible for auditory hallucinations. The need to ener-
gically pursue alternative treatment options to reduce
burden and distress from hallucinations was also
pointed out as an area of priority.
There was broad agreement in support of increased
collaborative efforts. Strategies for reporting and shar-
ing information and for standardization tasks and oper-
ating procedures were extensively discussed. There
was a consensus that strategies such as pooling data
and multisite international studies would be immensely
valuable. A contact list of individuals interested in
collaborating in such studies is now being collated
(Flavie.waters@health.wa.gov.au), and the list is available
on the Consortium website (hallucinationconsortium.org).
Finally, procedural matters were discussed at lengths.
A recurring theme revolved around ensuring that research
methods and procedures were of the highest scientific
quality and that only tasks representing state-of-the art
in science be used. Protocols also need to be adequately
equipped and flexible enough to assess dimensions of
hallucinations in different population groups.

Conclusions
The top 16 goals facing auditory hallucination research
are now incorporated in the Consortium’s new strategic
plan, with recommendations that researchers be en-
gaged with, and organize their activities around these
research initiatives. Moving forward on these issues
will require substantial research progress and a long-
term investment. The working groups have been encour-
gaged to pursue their goals as identified in the meeting
and propagate action by encouraging others to get in-
volved. Biannual meetings are planned to provide
updates on progress, present novel findings, and extend
the focus to hallucinations in other modalities. The Con-
sortium on Hallucination Research is closely aligned
with the National Institute of Mental Health’s Research
Domain Criteria initiative that is “committed to develop
new ways of classifying mental disorders based on
dimensions observable behaviors.” Enhanced interna-
tional research collaboration, theoretically-informed
advances, improvements in experimental design and
data pooling, and consensus-set goals for future re-
search, will hopefully allow for rapid progress to be
made in hallucination research.

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