Cognition 146 (2016) 206–216

Contents lists available at ScienceDirect

Cognition

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

The effect of auditory verbal imagery on signal detection in hallucination-prone individuals

Peter Moseley [a,b,*], David Smailes [a,c], Amanda Ellison [a], Charles Fernyhough [a]

[a] *Psychology Department, Durham University, South Road, Durham DH1 3LE, UK*
[b] *School of Psychology, University of Central Lancashire, Preston PR1 2HE, UK*
[c] *Department of Psychology, Leeds Trinity University, Horsforth, Leeds, LS18 5HD, UK*

A R T I C L E I N F O

Article history:
Received 17 April 2015
Revised 17 September 2015
Accepted 19 September 2015
Available online 1 October 2015

Keywords:
Auditory imagery
Inner speech
Hallucinations
Imagery–perception interaction

A B S T R A C T

Cognitive models have suggested that auditory hallucinations occur when internal mental events, such as inner speech or auditory verbal imagery (AVI), are misattributed to an external source. This has been supported by numerous studies indicating that individuals who experience hallucinations tend to perform in a biased manner on tasks that require them to distinguish self-generated from non-self-generated perceptions. However, these tasks have typically been of limited relevance to inner speech models of hallucinations, because they have not manipulated the AVI that participants used during the task. Here, a new paradigm was employed to investigate the interaction between imagery and perception, in which a healthy, non-clinical sample of participants were instructed to use AVI whilst completing an auditory signal detection task. It was hypothesized that AVI-usage would cause participants to perform in a biased manner, therefore falsely detecting more voices in bursts of noise. In Experiment 1, when cued to generate AVI, highly hallucination-prone participants showed a lower response bias than when performing a standard signal detection task, being more willing to report the presence of a voice in the noise. Participants not prone to hallucinations performed no differently between the two conditions. In Experiment 2, participants were not specifically instructed to use AVI, but retrospectively reported how often they engaged in AVI during the task. Highly hallucination-prone participants who retrospectively reported using imagery showed a lower response bias than did participants with lower proneness who also reported using AVI. Results are discussed in relation to prominent inner speech models of hallucinations.

1. Introduction

1.1. Auditory verbal hallucinations and inner speech

Auditory verbal hallucinations (AVHs) are the experience of hearing a voice in the absence of any speaker. Although commonly associated with a diagnosis of schizophrenia, AVHs also occur in around 1.5–3% of the healthy, nonclinical population (Tien, 1991). There is emerging evidence that the predisposition to AVHs may lie on a continuum, ranging from individuals who frequently experience, to individuals who rarely or never report, hallucinations (Johns & van Os, 2001; Johns et al., 2014). A fruitful area of investigation is therefore to investigate whether cognitive traits and biases associated with hallucinations in clinical populations are shared by individuals in the general population who report frequent hallucinatory experiences (Badcock & Hugdahl, 2012).

The most prominent cognitive model of AVHs suggests that they occur when an internal mental event (such as inner speech or auditory verbal imagery – AVI) is misattributed to an external source (Ditman & Kuperberg, 2005; Frith, 1992; Jones & Fernyhough, 2007b). This strand of research has been embedded in the source monitoring framework, which attempts to explain how we make judgements regarding the origin of information (i.e., its source; Johnson, Hashtroudi, & Lindsay, 1993). Specifically, an externalising bias in reality monitoring, which refers to the ability to distinguish between internally generated and externally generated perceptions, has been linked to AVHs (Bentall, Baker, & Havers, 1991). Externalising biases have variously been linked to excessively vivid mental imagery (Aleman, Böcker, Hijman, de Haan, & Kahn, 2003), and low cognitive effort/intrusiveness associated with mental imagery (Jones & Fernyhough, 2009; Morrison, Haddock, & Tarrier, 1995). On a mechanistic level, forward models may be involved in predicting the sensory consequences of motor

* Corresponding author at: School of Psychology, University of Central Lancashire, Preston PR1 2HE, UK.
E-mail address: pmoseley@uclan.ac.uk (P. Moseley).

http://dx.doi.org/10.1016/j.cognition.2015.09.015
0010-0277/© 2015 The Authors. Published by Elsevier B.V.

processes, and successful prediction via an efference copy may be one way in which self-generated actions are experienced as such (Frith, Blakemore, & Wolpert, 2000). Aberrant efference copy mechanisms could therefore underlie the misattribution of internal mental events to an external, non-self source (Ford & Mathalon, 2005).

Reality monitoring for verbal stimuli has typically been assessed using source memory paradigms, which require participants to recall whether words were spoken by the experimenter or by themselves. A common finding is that patients with a diagnosis of schizophrenia who hallucinate, compared to those who do not hallucinate, are more likely to misremember words as having been spoken by the experimenter, but do not make the reverse error (e.g., Brunelin et al., 2006; Woodward, Menon, & Whitman, 2007). That is, participants who hallucinate tend to show an 'externalising bias' on reality monitoring tasks. Consistent with continuum models of AVHs (Van Os, Hanssen, Bijl, & Ravelli, 2000), non-clinical samples who report higher levels of hallucination-proneness also show a similar pattern of responding on reality monitoring tasks (Brookwell, Bentall, & Varese, 2013; Larøi, Van der Linden, & Marczewski, 2004).[1]

However, these tasks are not ideally positioned to test models of AVHs that specify the misattribution of internal mental events such as inner speech, for two main reasons: (1) they are not 'online' measures (source memory tasks, for example, are 'offline' in that they require participants to decide who generated words earlier in the testing session); (2) they are either not specific to monitoring of speech or, if they are, are likely to use 'overt' (out loud) speech, as opposed to engaging the participant in auditory verbal imagery or inner speech. This limits the applicability of the results to inner speech models of AVHs, because it assumes that overt vocalisation in an experimental situation utilises the same mechanisms as covert or inner speech. Although there is evidence that overt and covert speech share cognitive and neural mechanisms, particularly in relation to the motor system (Alderson-Day & Fernyhough, 2015; Perrone-Bertolotti, Rapin, Lachaux, & Lœvenbruck, 2014), any inferences from studies using overt speech about the nature of covert speech are necessarily indirect, and based on the assumption that similarities between the two are more significant than the differences.

A similar line of research has attempted to engage the participant in an 'online' decision making process, referred to as 'reality discrimination', requiring participants to immediately respond as to whether a perception was internal or external (in contrast to the 'offline' decisions required in a source memory task, which typically require a decision to be made at a later time point, e.g., Woodward et al., 2007). Reality discrimination tasks typically take the form of signal detection tasks, in which the participant must decide whether a voice was present in a burst of noise. In these tasks, hallucinating patients tend to show a bias towards responding that a voice is present in the noise (Varese, Barkus, & Bentall, 2012). In a non-clinical sample, participants who reported more hallucinatory experiences also showed the same bias in responding (Barkus et al., 2011). These findings have been linked theoretically to the reality monitoring tasks described above, as providing evidence linking AVHs to an externalising bias (Brookwell et al., 2013). It is unclear, however, to what extent performance on auditory signal detection tasks relates to inner speech/AVI processes, since participants are not specifically instructed to use imagery during the task. One way to address this concern would be to employ a paradigm that requires participants to engage in covert AVI, whilst simultaneously detecting the presence or absence of a similar auditory verbal stimulus.

1.2. Mental imagery and perception

Previous research on the interaction between mental imagery and perception has come closest to meeting the two criteria outlined above (engaging participants in an online task, and controlling the mental imagery they generate while performing the task). Perky (1910) carried out a series of experiments that suggested that visual imagery interfered with the simultaneous perception of a visually presented stimulus (subsequently referred to as the Perky Effect). For example, participants who engaged in visual mental imagery of an object took longer to detect a visually presented stimulus of the same object than did participants who did not generate any mental imagery. This was taken to indicate that, since mental imagery and perception could be confused, they must rely on similar mechanisms.

However, others have found that mental imagery actually facilitates perception in the visual modality (Peterson & Graham, 1974). This finding has also been replicated in the auditory modality; for example, Farah and Smith (1983) engaged participants in auditory imagery of a pure tone, whilst simultaneously requiring them to detect a similar tone in noise. Participants were therefore required to distinguish between self-generated, internal mental imagery and an external stimulus. Using auditory imagery facilitated perception of the tone, although the task used did not include trials with no signal present, and so signal detection analysis was not reported. Findings on the interaction between imagery and perception have, therefore, been equivocal. More recently, Aleman et al. (2003) used a similar paradigm with a sample of patients with a diagnosis of schizophrenia, showing that the 'gain' on perception of a pure tone due to auditory imagery was strongly correlated with hallucination severity. This finding was interpreted as reflecting an over-reliance on top-down processes in hallucinating patients (which could also be related to a bias towards labelling internal imagery as external).

One problem with these studies is that they do not measure the effect of imagery on the tendency to *falsely* detect a signal in noise,[2] because there is always a signal present. This is a key variable when linking performance to the tendency to hallucinate, and also when performing signal detection analysis. From the data presented by Aleman et al. (2003), for example, it is not possible to tell whether the 'gain' on perception was due to a change in sensitivity (an increased ability to distinguish signal from noise), or a change in response bias (i.e., participants being more willing to respond that a tone was present when using imagery). The previously discussed literature relating to biases in reality monitoring/discrimination would imply that it may be the latter. Imagery–perception interaction tasks, though, have the advantage of directly engaging participants in internal mental imagery (as opposed to speaking aloud), and requiring them to distinguish whether any subsequent perception was internally generated or not, hence addressing the concern about reality discrimination tasks described above. As well as being informative on the nature of mental imagery, this makes the tasks ideal for testing inner speech models of AVHs.

1.3. Valence and externalising biases

A further question stemming from inner speech models of AVHs relates to what may cause one instance of inner speech to become misattributed, but not another instance. As discussed, source monitoring theories may appeal to vividness of mental imagery and the effort associated with cognitions, but theories of AVHs

[1] Although meta-analytic evidence robustly shows that externalising biases are associated with hallucinations in clinical and non-clinical populations, it is, of course, possible that these are a result, rather than a cause, of experiencing hallucinations.

[2] Farah and Smith (1983), however, note that many participants, when using auditory imagery of a pure tone, reported hearing the tone at times discordant with when the tone was actually presented, implying that imagery may have cause false detections. These false alarm responses were not quantified, however.