Hearing voices as a feature of typical and psychopathological experience

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In press, *Nature Reviews Psychology*

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Acknowledgements

W.L.T was supported by an Australian National Health and Medical Research Council (NHMRC) New Investigator project grant (GNT1161609). C.F. was supported by Wellcome Trust grant WT108720.

Author contributions

W.L.T and P.M. are joint lead authors. All authors contributed to researching data for article, discussing the content, and writing, reviewing and editing the manuscript before submission.

Competing interests

The authors declare no competing interests.

Peer review information

Nature Reviews XXX thanks [Referee#1 name], [Referee#2 name] and the other, anonymous, reviewer(s) for their contribution to the peer review of this work.

Abstract

Hearing a voice in the absence of any speaker can be a significant feature of psychiatric illness, but is also increasingly acknowledged as an important aspect of everyday, non-pathological experience. This recognition has led to a growth of interest in voice-hearing in individuals without any psychiatric diagnosis, coupled with greater attention to the subjective experience of voice-hearing across diagnostic groups. Research has also focused on the overlap between some aspects of voice-hearing phenomenology and everyday experiences such as 'hearing' the voices of fictional characters and spiritual experience. In this Review, we synthesize research on the range of cognitive, neural, personal, and sociocultural processes that contribute to voice-hearing as it occurs in clinical, non-clinical, and everyday experience, with a particular emphasis on linking mechanism to phenomenology. Heterogeneous forms of voice-hearing can be understood in terms of differing patterns of association among underlying mechanisms. We suggest an approach to hallucinatory experience that sees it as partly continuous with everyday inner experience, but which is critical about whether continuity of phenomenology across the clinical/non-clinical divide should be taken to entail continuity of mechanism.

[H1] Introduction

Hearing a voice in the absence of any speaker has long been associated with severe mental illness. Voice-hearing has been proposed as a cardinal symptom of the schizophrenia spectrum disorders, with up to 80% of those with a diagnosis of schizophrenia reporting hearing voices at some point over their lifetime[1]. Voice-hearing is increasingly recognized as a feature of other psychiatric conditions, including bipolar and depressive disorders[2], post-traumatic stress disorder[3], and borderline personality disorder[4]. Syndromes with neurological origins, such as Parkinson's disease[5], temporal lobe epilepsy[6], and migraine[7], also involve hallucinatory experiences (although not always in the auditory realm).

Notably, voice-hearing also occurs in a small but significant portion of the general population without a mental health diagnosis[8]. In the absence of distress, voice-hearing can be a significant feature of life for these individuals. Many features of voice-hearing also bear important commonalities with aspects of typical consciousness that would not be considered signs of mental disorder, such as engaging with fictional entities and imaginary companions[9]. This move towards recognizing that hearing voices is not necessarily pathological has led to the emergence of the term 'voice-hearing' as a replacement for the more medically-oriented 'auditory verbal hallucination', which has potential pejorative connotations.

Historically, there has been a focus on voices as primarily auditory experiences, likely due to the strong association between auditory hallucinations and the (controversial) diagnostic category of schizophrenia. However, the experience of voice-hearing is rarely confined exclusively to the auditory modality. A significant proportion of voices are described as 'soundless' voices, or as difficult to distinguish from regular thoughts[10,11]. Voice-hearing is also often accompanied by sensed presences (that is, feelings that someone is present in the immediate environment, often without clear sensory content) and experiences in other sensory modalities, including visual, somatic-tactile, olfactory, autoscopic **[G]** , and kinesthetic[12]. The

term voice-hearing thus encompasses a heterogeneous group of experiences that can vary widely in their auditory phenomenology. Although we favor this term, we will use the more conventional term ‘hallucination’ when discussing clinically significant experiences that are specific to non-auditory modalities.

In parallel with the growing recognition of the phenomenological complexity of voice-hearing, there has been an increase in research activity examining the etiology and maintenance of the voice-hearing experience. In contrast to the ‘deficit model’ of traditional biomedical psychiatry, which sees voice-hearing as resulting from a dysfunction in normal brain processes, voice-hearing is increasingly understood as a varied phenomenon which can emerge from distinct causal pathways. This variability has important implications for treatment in cases where voice-hearing experiences are distressing[13]. Research has accordingly begun to focus on voices as an interesting and important aspect of the diversity of typical human inner experience, rather than as necessarily the product of a ‘broken brain’.

In this Review, we examine the state of research on voice-hearing that incorporates experiences ranging from the distressing, disabling hallucinations of severe mental illness to everyday experiences. We begin by describing the varied kinds of voice-hearing experience, why they are sometimes distressing, and how their phenomenological features might differ across clinical and non-clinical categories. The full variety of voice-hearing experiences is then explored in light of the cognitive, neural, personal, and sociocultural mechanisms that have been implicated in its etiology, maintenance, phenomenological variability, and clinical significance, including some mechanisms likely to operate across sensory modalities. We examine the present state of the ‘continuum’ hypothesis, whereby such experiences exist on a spectrum from mild, transient experiences to frank clinical disorder, with significant variability in between. Finally, we illustrate how considering these three categories of clinical, non-clinical and everyday voice-hearing can help researchers understand the multiple possible pathways to voice-hearing, and

recommend an agenda for future research on this complex, varied, and significant feature of human experience.

[H1] Phenomenology of voice-hearing

The characteristics of voice-hearing in clinical and non-clinical cohorts have been well-documented[8,11,14–26]. Phenomenological features associated with voice-hearing can differ somewhat across these categories, but there are actually more shared commonalities than differences[27]. These phenomenological similarities and differences, organized into perceptual-sensory, cognitive, and affective domains, are summarized in Table 1. Prevalence estimates for voice-hearing in the general population vary, with lifetime figures between 0.6% ('Have you ever heard sounds, music, or voices which other people can't hear?'[28]) and 84% (at least one lifetime experience of 'brief, auditory hallucinations of the voice type', including sleep-related experiences)[29]. These estimates depend on what the participant believes is being asked of them, signalling a need for clear and consistent terminology.

Throughout this Review, we broadly categorize voices into three groups: clinical voices associated with distress or need for clinical care or treatment; non-clinical voices that are frequent and often recurring, but not associated with distress or mental health diagnoses; and everyday voices encompassing experiences such as inner speech or erroneously hearing one's name being called. We do not claim that these are 'true' categories or natural kinds; rather, we suggest that they provide a useful way to think about variability in these experiences. Also note that prevalence statistics cited here do not always clearly map onto one of these categories. For example, voice-hearing prevalence in the general population typically includes experiences described in both our non-clinical and everyday categories.

[H3] Clinical voices

In the clinical group (often, but not always, involving a diagnosis of schizophrenia), psychosis patients tend to report hearing speech, often with some non-verbal sounds, with voice onset typically in adolescence or early adulthood[27]. These experiences occur on a continuum ranging from fully to 'mixed' auditory percepts (comprising features common both to speech percepts and regular thoughts), to soundless or thought-like voices[11]. Perceptual-sensory characteristics of clinical voices tend to exhibit high variability from person to person as well as within a single person. Frequency and duration can fluctuate from constant, daily voices to those that only arise during acute psychosis; volume can range from a whisper to shouting, although conversational levels are common; clarity can vary from incoherent to sharp; a single voice can predominate, but multiple voices (up to a crowd) are possible; localization can comprise internal or external voices or both; linguistic complexity can differ, although repetition of phrases is typical; and second- or third-person address is most likely[20,24,30,31].

Cognitive characteristics of clinical voices seemingly exhibit less variation relative to perceptual-sensory characteristics. Levels of conviction as to the veracity of voices tend to be high; there is limited perceived controllability; voices often have an autonomous, non-self quality; and beliefs regarding voice origin may incorporate a mixture of psychological and environmental factors. There are is some variability in when and how patients interact and comply with their voices, but vivid personification of known (or familiar) identities is common[21,24,25].

Affective characteristics of clinical voices primarily relate to facets of content, distress, and functional interference, for which there appears to be broad consistency in patient experience. Voice content can involve a rich array of themes (including neutral or positive voices), but critical, derogatory, or threatening voices are most widespread[32], and typically have substantial negative life impacts[20,21,24]. Somatic or bodily sensations, such as tingling or burning on the skin, might also accompany these experiences[11].

154

155 *[H3] Non-clinical voices*

156 Non-clinical voice-hearing (often used interchangeably with 'healthy voice-
157 hearing' in the literature) refers to frequent, recurring experiences, of comparable
158 complexity and/or persistence to that in clinical groups, but associated with little
159 distress and no mental health diagnosis. The lifetime prevalence of non-clinical and
160 everyday voices has been estimated as somewhere between 5% and 15% of the
161 general population having, at minimum, experienced one-off or fleeting voices[29].
162 However, prevalence estimates can vary depending on the methodology employed
163 and specific questions asked, or even the discipline conducting the study (for
164 instance, psychology versus anthropology). Of note, non-clinical (relative to clinical)
165 voice-hearing typically has an earlier age of onset; occurs less frequently; is
166 associated with greater perceived control; involves less negative content; and causes
167 negligible emotional and functional disturbance[8,19,22,23,33,34]. Variability in other
168 phenomenological features implies significant overlaps in these experiential facets
169 across cohorts, with little utility for predicting mental health status[27].

170 There have been calls for research to investigate how non-clinical voice-
171 hearers can temper negative emotions and sustain functional behaviors in the face of
172 what many would perceive as aberrant, frightful events, and whether voices may
173 serve some adaptive function that negates the need to seek psychological care[19,33].
174 A minority of individuals in this category do transition to psychotic illness, but this is
175 often underpinned by secondary precipitants, such as pre-existing anxiety or
176 depression, or ongoing life stressors[14,18,20,35]. Many non-clinical voice-hearers report
177 spiritual beliefs, and voices are often interpreted as communication from deceased
178 individuals[36–38].

179 Other research has focused on the extent to which spiritual practice, and, in
180 particular, control over the experience, influence affective aspects of voice-hearing[39].
181 In particular, it was found that increased control was associated with reduced

distress and improved functioning, although clearer delineation between discrete types of control is needed. Some spiritual practices involve cultivating and controlling voice-hearing experiences that might have initiated spontaneously[40]; in other cases, voice-hearing experiences may have started as a result of such practices[38]. Examining non-clinical voice-hearing, unfettered from the confounds of broader psychopathology and medication effects, offers an opportunity to discern the fundamentals of this distinctive phenomenon, as well as its transdiagnostic operation across the psychosis continuum.

[H3] Everyday voices

What we refer to here as 'everyday' voices typically encompasses common and benign misperception of auditory events, such as the occasional fleeting, unexplained voice, or experiences involving imaginary companions. These occurrences can be sporadic, with their incidence heightened (as in psychosis) by certain internal factors such as sleep disruption[41] and stress[42], as well as external conditions, including noisy settings or even silence[43]. Associated content is typically mundane or negligible, and there is little emotional significance attached. A possible exception lies in the case of bereavement hallucinations (perceptual experiences of a person, usually a loved one, who has passed away, potentially involving multiple senses, such as hearing their voice, seeing their image, and so on), which can be associated with psychological distress[44].

Many everyday voice-hearing experiences include elements that appear alien to the self. For example, inner speech (covert, self-directed speech or verbal thinking), particularly its misattribution to an external source, is considered to have a significant mechanistic role in cognitive and neural models of voice-hearing. There is heterogeneity in inner speech[45], but one replicated finding is that it is not uncommon for individuals to report hearing the voices of other people in their inner speech (for

example, by endorsing an item such as 'I hear other people's actual voices in my head, saying things that they have never said to me before.')[46].

Another example of everyday voice-hearing is 'hearing' the voices of fictional characters when reading. A study of more than 1,500 respondents predominantly from English-speaking countries (such as the UK, US, Australia, Canada, and Ireland) found that around one in seven experienced such voices with as much vividness as hearing an actual person[47]. More than half of a sample of professional writers reported 'hearing' the voices of their characters[48]. A further example is the experience of engaging with imaginary companions. Although imaginary companions are usually associated with childhood, one study found that 7% of the large sample of English-speaking adults mentioned above reported currently having an imaginary companion (versus 41% having had such a companion in childhood). For almost half of participants with any experience of having an imaginary companion, engaging with such a companion involved regularly hearing their voice[49]. Hearing the voices of others in the absence of any speaker thus appears unexceptional as an aspect of human inner experience.

Taken together, these phenomena are consistent with the dominant view that regular sensory perception involves a process of 'controlled hallucination'[50]: the nervous system actively predicts what is in the environment rather than passively receiving information about it. Reports of such everyday voice-hearing phenomena also align with growing evidence that hallucinations can be readily elicited in healthy individuals in experimental situations[51].

[H1] Mechanisms of voice-hearing

Research has investigated the cognitive (see Table 2), neural, personal, and sociocultural mechanisms that might generate voice-hearing experiences across the three categories of voice-hearing experiences described above. Although these mechanisms are presented here as categorically distinct, they are not entirely

conceptually separable, and in fact typically exert multifarious influences on one another.

[H3] Cognitive mechanisms

Although individuals with a diagnosis of schizophrenia typically show wide-ranging cognitive impairments[52], it is difficult to establish which, if any, are specific to voice-hearing because of comorbid symptoms and the confounding effects of antipsychotic medication[53]. One study found some impairments in executive function, working memory, and verbal intelligence, but not in other cognitive measures, for non-clinical voice-hearers compared to non-voice-hearing controls[17].

Other studies have taken a narrower, theoretically-driven approach. For example, early cognitive models of voice-hearing suggested that clinical voice-hearing might result from misattributing internal mental events (such as inner speech) to an external source[54]. This externalizing bias in source monitoring was supported by evidence from a source memory task, in which participants were asked to recall the origin (self or non-self) of previously presented verbal stimuli; hallucinating psychosis patients were more likely to externally misattribute a self-generated word as non-self-generated compared to non-hallucinating psychosis patients or non-clinical controls[54,55]. Numerous studies have reported similar findings, with meta-analytic evidence suggesting that such external misattributions are associated with hallucinations in both clinical and non-clinical samples[55]. However, several studies have failed to replicate these findings[56–58], with the discrepancy possibly caused by variability between studies, such as in the specific attributes of the tasks used.

Source-monitoring (or self-monitoring) theories of voice-hearing have been linked to ‘comparator model’ accounts. These accounts posit that dysfunctional efference copies (internal copies of motor signals, sent between motor and sensory brain regions to predict and typically suppress sensory cortical activity) could lead to

feelings of alienness or that one's own actions are not self-generated[52,59,60]. Source-monitoring theories are also consistent with accounts of hallucination proneness linked to population-wide variability in the vividness of mental imagery[61], predicting that vivid mental imagery would be more likely to be externally misattributed.

Externalizing bias accounts of hallucinations are also supported by evidence from auditory signal detection tasks in which participants must detect speech embedded in noise (Figure 1a). Clinical and non-clinical voice-hearers have a lower threshold for responding that there was a voice in the noise compared to non-voice hearers[62], and therefore are more likely to respond that a voice was present on noise-only trials (Figure 1b). These results have been interpreted to suggest that biases towards responding that signals are external are associated with hallucinations. However, evidence is mixed regarding whether this response bias is accompanied by a decrease in detection sensitivity (the perceptual ability to distinguish speech signals from noise)[63].

Although some researchers assume that biases in source monitoring and auditory signal detection tasks reflect a common underlying cognitive mechanism[55], there is little evidence for this interpretation. Indeed, source monitoring and signal-detection explanations of voice-hearing operate, to some extent, at different explanatory levels that are not mutually exclusive[64]. Whereas source-monitoring tasks assess memory-related decision-making in relation to relevant mnemonic cues[65], biases in auditory signal detection might reflect over-weighting of top-down processes. For example, according to predictive processing accounts the nervous system makes predictions about the external world and updates these predictions on the basis of discrepancies between these predictions and observation (prediction error). In a predictive processing framework, biases in auditory signal detection tasks might be due to overweighting expectation relative to observation[66].

The role of top-down processes in voice-hearing is also suggested by evidence that voice-hearing participants, regardless of clinical status, are more

susceptible to ‘conditioned hallucinations’ than non-voice-hearing participants. That is, voice-hearing participants are more likely to report hearing tones that are not present in response to a visual stimulus after an auditory and visual stimulus are repeatedly paired[67]. Other studies have shown that prior expectations for speech, as assessed by responses to ambiguous speech stimuli, might be present in voice-hearers, even without experimental induction via conditioning[53]. These prior expectations are associated with performance in the conditioned hallucinations paradigm, such that clinical voice-hearers who were more likely to detect speech in ambiguous stimuli were also more susceptible to conditional hallucinations[68].

Bottom-up perceptual processes might also contribute to voice-hearing. For example, people with peripheral sensory deficits such as hearing impairment are predisposed to hallucinatory experiences[69]. Promising computational models of voice-hearing therefore take into account the integration of top-down and bottom-up signals[70].

Finally, voices may result from failures to inhibit and place into context intrusions from episodic memory due to failures in intentional inhibition[71,72]. In typical assessments of intentional inhibition, participants complete a variant of a continuous recognition task in which, during later task blocks, participants are asked to inhibit recognition responses based on earlier stimuli. Both voice-hearing psychosis patients[71,72] and participants in the general population reporting more hallucinatory experiences[73,74] exhibit impairments in intentional inhibition, suggesting that voice-hearing might reflect uncontrolled intrusive memories. However, one study found no impairment in intentional inhibition in a group of non-clinical voice-hearers[58]. This raises the possibility that impaired performance on intentional inhibition tasks might only be associated with voices in psychosis.

As outlined in this section, a number of cognitive mechanisms have been linked to voice-hearing in clinical and non-clinical groups. Further research is needed to clarify which cognitive mechanisms are specific to clinical (as opposed to non-

clinical) voice-hearing, as well as how different mechanisms may be associated with phenomenologically different kinds of voices.

[H3] Neural mechanisms

A variety of neural mechanisms have been put forward to account for voice-hearing in clinical and non-clinical groups. Neuroimaging studies that record brain activity while clinical and non-clinical participants hear voices (known as symptom-capture studies) have shown activation in regions including the inferior frontal gyrus, superior temporal gyrus, insula, and (para)hippocampus[75] during voice-hearing. These regions overlap with brain areas involved in inner speech[76], auditory signal detection[77], and auditory imagery[78,79].

Studies examining functional connectivity **[G]** point to aberrant fronto-temporal connectivity in both clinical and non-clinical voice-hearing individuals compared to non-voice-hearing controls. These findings suggest a functional model of atypical efference copy signalling between the inferior frontal speech production region and speech perception areas in the temporal lobe[80,81]. This model is supported by atypical N1 event-related potentials in response to self-generated (but not non-self-generated) actions in people with a diagnosis of schizophrenia[82]. The N1 component of the auditory event-related potential is taken as a marker of suppression of activity in cortical speech perception areas in response to receiving an efference copy signal during speech production. However, most auditory event-related potential findings show an association with psychosis, but do not show specific associations with voice-hearing[83].

Studies of structural connectivity **[G]** confirm atypical white matter connectivity linking frontal and temporal areas, particularly in relation to the arcuate fasciculus[84], in voice-hearers with a diagnosis of schizophrenia. However, findings regarding this white matter tract have been inconsistent[85]. Other structural neuroimaging studies find variation in patterns of brain folding in individuals with

schizophrenia who experience hallucinations in different modalities[86], and there is evidence that decreased length of the paracingulate sulcus (known to be significant in source monitoring) is associated with a greater susceptibility to hallucinations in patients with schizophrenia[87]. Taken together, these findings suggest that brain structure may be altered in clinical populations in ways that are specifically linked to hallucinations.

Voice-hearing is associated with atypicalities in brain networks activated when participants are not engaged in an explicit task (resting-state networks). Specifically, there are differences in patterns of interaction among the default mode network **[G]** and networks linked to cognitive control and salience, as well as those relevant to specific modalities of perceptual processing[88,88,89]. Resting-state auditory cortex hyperactivation has been implicated in voice-hearing in both clinical[90] and non-clinical[91] groups. These findings suggest that mechanistic explanations of voice-hearing may be sought in patterns of brain activation observable even when participants are not reporting on their own hallucinations or engaged in a specific task.

Evidence for atypical fronto-temporal signalling in clinical and non-clinical voice-hearers is consistent with the idea that voices result from a failure to predict the sensory consequences of one's actions[92]. Within the general predictive processing framework, such models have been understood as congruent with models of hallucination associated with an overreliance on strong priors[93], combined with compromised processing of prediction error, leading to non-veridical acceptance of perceptual hypotheses[94] (the brain's 'best guesses' about what is out there in the environment). Predictive-processing approaches to hallucinations also gain support from research on the role of striatal dopamine in perceptual inference[95]. For example, perceptual and reward expectations and striatal dopamine have been linked to behavior consistent with hallucination-like experiences in mice[96], consistent with

models suggesting a role for prior expectations in hallucinations, and with a large literature suggesting elevated dopamine levels in schizophrenia[97].

Finally, data showing activation in right-hemisphere homologues of speech-production regions during voice-hearing[98], combined with behavioural findings that psychosis patients with hallucinations do not show a typical right-ear advantage[99] (more accurate reporting of stimuli presented to the right ear than the left ear when different speech stimuli are simultaneously presented to both ears), implicate atypical patterns of brain lateralization, particularly relating to language functions[100], in schizophrenia, consistent with explanations of voice-hearing as instances of auditory cortex hyperactivation and decreased cognitive control.

Research into the neural mechanisms underlying voice-hearing has employed a variety of methods to show altered patterns of brain processing and structure in clinical voice-hearers. In some cases, these patterns have also been shown to extend to non-clinical voice-hearers. Particularly where such findings support cognitive models, they offer hope for mechanistic explanations of the phenomenon, although there remain many gaps in current knowledge, and reasons to be cautious about assuming continuity of mechanism across the clinical/non-clinical divide.

[H3] Personal and sociocultural mechanisms

Certain personality traits, for instance involving heightened absorption (propensity for total immersion within one's thoughts or experiences), schizotypy (see Box 1), or openness to experience, are known to increase the likelihood of voice-hearing in certain cohorts[40,101]. When voice-hearing involves the experience of often personified voices in interaction with the self, it can be a highly social process[102,103]. Some accounts of the social nature of voice-hearing relate to its potential origin in the misattribution of inner speech to an external source. Inner speech is recognized to have interpersonal qualities, particularly a conversational or dialogic nature,

proposed to result from the internalization of linguistically-mediated social interactions, such as dialogues with caregivers, during development[104]. Other accounts suggest that voice-hearing is the result of atypical activation of social agent representations[10], such that voice-hearing experiences reflect hallucinations of communicative agents rather than simply auditory experiences. Agent representation may be particularly important for the role of social threat in distressing voice-hearing experiences[148]. Relatedly, loneliness and social isolation have been linked to voice-hearing, with voices and other psychosis-like experiences in the absence of social interaction playing a role analogous to phantom limbs in the absence of the amputated limb[105]. However, there is some evidence that only negatively appraised social exclusion ('social defeat') triggers hallucinations[106].

The social nature of voice-hearing is also apparent in its connections to trauma and dissociation (discontinuity or separation between one's thoughts and emotions, or even facets of self-identity). Dissociation is hypothesized to exert a two-fold influence between voice-hearing and trauma, via fragmentation of self components[107,108] (resulting from traumatic life events, including interpersonal losses and stressors) and as a mediator (where depersonalization was able to explain a specific portion of the variance in childhood abuse)[109,110]. The involvement of dissociation is underscored by the interpersonal nature of specific types of trauma, as well as the social relationships that some people share with their voices[103,111]. Moreover, early trauma has been shown to be a risk factor for psychosis[112–115], and in particular hallucination severity[116]. However, other reviews have been more critical about drawing firm etiological links between trauma and voice-hearing due to existing conceptual and methodological limitations, such as diagnostic ambiguities, consensus regarding the definition and measurement of childhood trauma, under-powered studies, and the lack of longitudinal research[117,118]. Nevertheless, trauma is often reported in conjunction with voice-hearing in clinical groups[119,120] and population-based studies[121,122].

However, closer inspection of mechanistic factors potentially related to trauma elicits more questions than answers. One model outlining possible pathways from trauma to psychosis has highlighted interactions among personal vulnerabilities and various kinds of intrusion[123], but the empirical evidence for memory intrusions is currently limited[124]. Although certain risk factors for voice-hearing have been documented (for example, childhood sexual abuse[121]), less is known about individual differences and protective factors (such as attachment or resilience) that may determine why some people with similar life and trauma experiences do not go on to develop voices (or vice versa).

Socio-demographic factors have also been linked to the propensity to hear voices, although it is often difficult to establish specificity to voices (as opposed to psychotic experiences more broadly). Some evidence suggests that, within psychosis, biological females are more likely to report voices[125,126]. Other socio-demographic factors such as ethnicity and migration status are well-established risk factors for psychosis[127], but their specific contribution to voice-hearing is less clear. Several studies have linked ethnic minority status to hallucinations[128,129]; one study indicated that migration was linked only to delusional ideation, not hallucinations[128]. Longitudinal research has found that cannabis use, childhood trauma, and ethnic minority status are linked to persistence of psychotic experiences over a period of six years[129], but these findings are not specific to voice-hearing.

A final set of mechanisms relate to cultural or subcultural influences. For example, the Fang ethnic group in Equatorial Guinea describe *mibili* as possession by evil spirits that manifests as auditory and visual hallucinations[130]. Cultural influences are complex and multifaceted, involving myriad interfaces along geographical, ethnic, and religious lines. Cultural expectations profoundly shape the definition, prevalence, experiential facets, and significance of voice-hearing, as well as levels of psychopathology and concomitant outcomes[131,132]. For example, one study found distinct differences in the phenomenological experiences of voice-

hearing in the context of schizophrenia across the United States, Ghana, and India[133]. The American sample mostly had an adversarial relationship with their voices, which involved themes of violence, and this was readily pathologized as indicative of mental illness; the Ghanian sample often linked their voices to a benevolent God, with whom they shared a social and positive relationship; and the Indian sample personified their voices, who were often kin, and these voices provided an adaptive function by dispensing advice or instruction[133].

Most existing studies examining cultural influences on voice-hearing have relied on rudimentary divides across national borders or between Western and non-Western cultures[133–138]. The lack of nuanced considerations inherent in such divisions is problematic for the field because globalization and the mass movement of people across borders over time means that homogeneous cultural settings are becoming increasingly rare. Outside of a Western medical disease model, voice-hearing may be less negatively regarded or pathologized, possibly due to fluid delineations between reality and fantasy as well as self and other[19,131], referred to as the concept of 'porosity'[38].

From a subcultural perspective, understanding voice-hearing as a personally significant aspect of human experience has taken on political force with the growth of the international Hearing Voices Movement[139]. This grassroots advocacy initiative focuses on personal empowerment and the de-pathologization of voices[140]. Its emphasis on positive acceptance and individual meaning-making denotes significant departures from, but also some overlaps with, conventional views espoused in psychiatry and psychology. Other examples of subcultural or religious influences on voice-hearing include the repositioning of the hallucinatory experiences of historical figures[141,142], or studying their attribution to *jinn* (invisible spirits) within Islam[143].

Religious affinity might serve as both a risk and protective factor in shaping voice-hearing[144,145]. For example, tentative evidence suggests that religious activity might serve as a coping mechanism for voice-hearing in Brazil[146], whereas in the

Netherlands religious affiliation has been theorized to add to the specificity and burden of these experiences[147]. Relatedly, unusual sensory experiences can be deliberately sought out in certain spiritual settings, such as indigenous use of psychotropic agents to invoke communication with the spirit realm[131,132] or contemporary rituals performed by psychics and mediums[40,148,149]. These practices stand apart from clinical voice-hearing in that they are highly valued, often replete with vivid detail, and accepted within shared cultural norms. Different pathways might therefore underlie these different voice-hearing experiences[150]. What cultural or spiritual beliefs like *mibili* and *jinn* may have in common is a collective pursuit of meaning by adapting interpretations of anomalous perceptual events to fit the broader cultural milieu. More research is needed to understand the mechanisms underlying such experiences.

It is thus evident that voice-hearing experiences do not occur in isolation, but are shaped by factors including early life trauma, sociodemographic and personality variables, and cultural and religious influences. The endeavor to understand voice-hearing experiences in their full complexity will benefit from situating them within the broad personal, social, and cultural contexts in which they occur.

[H1] Continuity and discontinuity

In the previous section we outlined a range of cognitive, neural, personal, and sociocultural mechanisms that might underlie voice-hearing experiences across clinical and non-clinical categories. A key question is the extent to which the transient and non-distressing voice-hearing experiences of individuals without need for psychiatric care lie along a continuum with recurring and distressing experiences in psychosis. According to diagnostic discontinuous models, non-clinical voice-hearing is only explicable in terms of phenomenology and processes also occurring in non-voice-hearers, and these are distinct from those underlying distressing experiences that characterize clinical voice-hearing (Figure 2a). By contrast, the continuum

hypothesis proposes that non-clinical voice-hearing is simply an attenuated version of psychotic experience, fundamentally of the same kind and perhaps reflecting an underlying continuous mechanism, phenotype or 'proneness'[1]. In continuous models, psychotic experiences might be directly related to distress and the need for treatment (Figure 2b) or could occur independently of distress and the need for treatment (Figure 2c).

Here, we do not aim to debate whether psychotic disorders represent an extreme manifestation of a continuous trait or latent factor in the population (such as schizotypy[151]), but focus instead on which specific aspects of voice-hearing might be continuous across the population in phenomenology or mechanism. A related question is the extent to which aspects of phenomenology and mechanism are linked, and via which facets of phenomenology and mechanism such linkages occur. A crucial question is whether any continuity of experience reflects common underlying cognitive and neural processes; in other words, whether continuity of frequency and phenomenology translates to continuity of mechanism. The answer to this question will be informative about whether voice-hearing in different groups should be considered as representing the same kind of experience.

[H3] *Continuity of experience*

At its most basic level, voice-hearing could be continuous in frequency across the population, with some people reporting regular voices, compared to others who report only occasional experiences. Epidemiological data provides evidence for occasional psychotic-like experiences in the general population, with one meta-analysis suggesting a median lifetime prevalence of 7.2% (and an annual incidence of 2.5%)[151], involving similar risk factors (such as cannabis use and stress[127]) as in psychosis. Numerous standardized self-report assessments show variability in the frequency of hallucinations in the general population at lower rates than in psychosis[152]. Although it has been argued that such scales may ask about

544 fundamentally different experiences[153], it is not contentious to state that some forms
545 of voice-hearing are present in the general population, with varying frequencies.
546 There may also be continuous variation in aspects of the voice-hearing
547 experience itself, such as associated distress (Figure 2b). Recent research with non-
548 clinical voice-hearers shows that, as in psychosis, distress can vary independently of
549 voice-hearing frequency[22,36,37], and scales administered in the general population
550 show some variability in ratings of distress associated with hallucinations[154]. Others
551 have argued that distress might be discontinuous between clinical and non-clinical
552 populations[19,153] (Figure 2c), appearing predominantly in those with a diagnosis of (or
553 at risk for) psychosis.
554 Other aspects of the phenomenology of voices might also vary across the
555 population. While volitional control is typically low or non-existent in psychosis, non-
556 clinical voice-hearers often report at least some level of control[39]. Additionally, recent
557 studies have shown that personification varies within clinical and non-clinical
558 categories[155,156], with individuals within both groups reporting different levels of
559 'person-like' voices. Although no research has assessed personification of infrequent
560 hallucinatory experiences in the general population, proneness to such experiences
561 has been associated with the tendency to assign personality characteristics to
562 neutral auditory-verbal stimuli[157]. These findings suggest that attributions of social
563 agency might vary within and between groups who report voices.
564
565 [H3] *Continuity of mechanism*
566 Evidence regarding continuity of mechanism across different forms of voice-
567 hearing is mixed. To take an oft-cited example, voice-hearing might result from
568 biases in source monitoring or auditory signal detection[54,55]. Evidence of such biases
569 in voice-hearers with psychosis is often reported[62,158,159]. Signal detection biases
570 have been found in non-clinical populations[55,57]; however, evidence for source-
571 monitoring biases is more mixed[55–57]. Evidence is also mixed regarding the roles of

attention[160,161] and intentional inhibition[58,71,73,74] across clinical and non-clinical voice-hearing, with some studies reporting differences between voice-hearing and non-voice-hearing groups, and some not. One interpretation of these discrepancies is that only some cognitive mechanisms associated with voice-hearing vary continuously, whereas others are discontinuous, and contribute only to some forms of voice-hearing.

The validity of the continuum hypothesis as applied to voice-hearing therefore seems to depend on the answer to the question: a continuum of what? A related question concerns whether any such continuum has an explanatory function. Similar to debates surrounding the utility of psychiatric diagnostic practices[162], it is important to consider whether investigating continuity is useful clinically or valid scientifically. One solution has been to suggest multiple continua across which voice-hearing might vary, such as frequency, distress, or vividness, allowing for an exploration of variance and covariance within and between these continua[163]. This approach could also be clinically helpful for developing treatments for people with distressing voices (for example, improving detection of people at risk for developing psychosis, or more precise targeting of therapeutic options for voices). Another option is to focus less on putative continua and more on underlying commonalities: that is, factors that might not vary continuously between individuals, but rather play a common causal role in voice-hearing across different kinds of experiences.

[H1] Multiple pathways to voice-hearing

In this section, we illustrate how multifactorial consideration of the varying phenomenology of voice-hearing in everyday, non-clinical, and clinical categories can generate testable hypotheses about how various building blocks underlying voice-hearing might interrelate across the range of experiences. We do not set out to present a comprehensive model of voice-hearing[164]; there are too many gaps in current knowledge to propose a feasible integrated model linking cognitive and

neural mechanisms to phenomenological features. Rather, we hope to offer a functional approach that can be used to set a research agenda to advance the field.

To this end, Box 2 describes three putative instances of voice-hearing, one from each of our main categories: an individual with relatively frequent experiences of the voice of a deceased loved one in the absence of distress (everyday voice-hearing); an individual with particular spiritual beliefs within a specific cultural context (spiritualism/mediumship; non-clinical voice-hearer); and an individual hearing voices in the context of psychosis (clinical voice-hearer). These examples have been chosen to illustrate how common and distinct processes interact in generating the varied phenomenology of voice-hearing, including in complex ways that remain to be fully elucidated. Another important point to reiterate is that the overlap of phenomenology across groups is considerable, but should not be taken as necessarily entailing continuity of mechanism[163]. Indeed, we propose considerable variation in mechanism even within our groups, with differing patterns of association among top-down and bottom-up mechanisms potentially underlying different phenomenological clusters. The examples should therefore be read as indicative of how constituent processes might interrelate in line with select phenomenological facets of voice-hearing.

Comparisons across the three examples can help illustrate our arguments about continuity and discontinuity across mechanisms and phenomenological features. The subjective experience of voice-hearing in our everyday example is as vivid, clear, and complex as the distressing hallucinations experienced in our clinical case. In our non-clinical example, voices are shaped by underlying cultural beliefs in a way that is less apparent in both the everyday and clinical examples. Deficits in peripheral sensory systems, such as hearing loss, play a role in the everyday example but not in the non-clinical or clinical cases. To be clear, the argument is not that hearing loss always features in everyday voices and never in clinical ones. Rather, it is that causal factors underlying voice-hearing can dip in and out across

groups in ways not easily described as continuous or discontinuous with phenomenology.

Another interesting point is that the predictive processing framework is implicated in all three examples but takes different forms in each. In the everyday example, there is a high expectation of hearing a particular voice. In the non-clinical example, there are stronger priors for hearing speech stimuli in all auditory stimuli[53] which are enhanced by learning and cultivation processes relevant to the subcultural context. In the clinical example, atypical processing of prediction error, in addition to strong speech priors, is implicated. Although the same general mechanism is thus involved in each example (predictive processing), the biases involved take different forms and shape phenomenology in distinct ways.

Comparison of phenomenological and mechanistic features across voice-hearing groups is instructive in other ways. Our example of non-clinical voice-hearing is particularly dependent on processes that manifest at the personal-sociocultural level of explanation, rather than at the neural or cognitive levels. This example highlights how paying attention to neural and cognitive processes at the expense of personal and sociocultural ones—as research on voice-hearing has tended to do—might make it more challenging to account for the range of voice-hearing experiences.

Our three examples in Box 2 also shed light on ongoing debates about continuity in voice-hearing experiences. Constituent processes might be involved across the three groups with no simple gradation of mechanism, and some degree of commonality in phenomenology. That said, one pattern that emerges is the increase in the number of relevant features as we progress from everyday to clinical voices. This increase in relevant features could suggest that clinical voice-hearing is indeed characterized by a greater number of underlying mechanisms (and hence, perhaps, phenomenological features). Alternatively, it could be that there has been less research on everyday and non-clinical voice-hearing, in which case the absence of

evidence should not be taken as evidence of absence. The present state of research is not sufficient to distinguish between these two possibilities.

Owing to a lack of relevant evidence, our proposed links between mechanism and phenomenology in this section are largely speculative, and highlight areas where intensive research will be particularly valuable. Indeed, an overarching question for future research concerns the extent to which researchers might ever expect to be able to map phenomenology onto mechanism. At a minimum, researchers will need to address the complexity of interactions among processes at different levels of explanation, and how this might lead to different kinds of voice-hearing.

[H1] Summary and future directions

Voice-hearing is a diverse phenomenon experienced in some form by a significant proportion of the population (with or without mental health diagnoses), with multiple cognitive, neural, personal, and sociocultural mechanisms influencing its etiology, dynamic development, and phenomenology. Our approach to understanding how multiple mechanisms can constellate in different patterns between and within our three groups of voice-hearers highlights that we cannot assume any simple continuity of mechanism or experience across the spectrum from everyday, through non-clinical, to clinical voice-hearing, even when many aspects of subjective experience are shared. Importantly, although our focus here has been on voice-hearing, many of the processes described are modality-general[89] and thus likely to feature in hallucinations across other modalities (see Box 3). Determining which processes generalize across modalities remains an empirical question that should guide future research.

The predominant factor that determines diagnostic group membership is the occurrence of distress. Voice-hearing occurs in a variety of forms that do not significantly influence functioning, and which can even have beneficent, if not merely neutral, effects on the individual. These offer hope for advancing understanding of

many aspects of typical, non-pathological psychological functioning, such as the nature of inner speech[165] and cognitive processes such as source monitoring[57]. Pinning down exactly why some voices are distressing is a complex and challenging task, and one that lies beyond the scope of our article (see ref[166] for a recent interdisciplinary attempt).

Our Review did not cover therapeutic options for distressing voices[167,168]. However, the fact that many voice-hearing experiences are intensely distressing makes the search for further knowledge about links between phenomenology and mechanism even more pressing. If voice-hearing is as varied an experience as the research reviewed here suggests, psychological therapies will arguably be best targeted at particular subtypes of phenomenology to the extent that they can be tied to underlying mechanisms[169]. These patterns of association are likely to be highly complex, and 'one size fits all' approaches that do not consider specificity of phenomenology and mechanism might fail to deliver the therapeutic benefits that those troubled by distressing voices desperately deserve. In particular, there is an urgent need to improve understanding of which early-developing manifestations of voice-hearing relate to future distress, and which remain largely benign, so that effective therapeutic interventions for distressing voices can be developed and deployed.

The co-occurrence of trauma in some voice-hearing individuals leaves several questions unanswered. Although clear associations with childhood sexual abuse exist[116,121], explicit causal links are unverified[170], and contradictory findings remain in relation to other forms of trauma[119,120]. Preliminary evidence supports distinct voice-hearing subtypes possibly underpinned by a trauma-related phenotype[31]. Future studies could ask how the precise nature of traumatic events aligns with voice-hearing and its phenomenological correlates[114]. Complex interactions among dissociation and other etiological factors, such as memory and cognitive inhibition, also need further study.

712 In non-clinical voice-hearing, more research is needed on cognitive
713 processes, with a particular focus on attentional, inhibitory, and source-monitoring
714 abilities. Inconsistencies in the literature relating to this group, for example, around
715 paracingulate sulcus morphology[91,171] in different non-clinical samples (possibly
716 reflecting different recruitment methods and/or inclusion criteria), might be resolved
717 by new evidence for previously unseen phenomenological heterogeneity in such
718 groups[163]. More research is also needed on how sociocultural factors such as cultural
719 beliefs interact with cognitive and neural mechanisms to shape experiential facets of
720 non-clinical voice-hearing, and on what factors, including age of onset and distress,
721 distinguish clinical and non-clinical voice-hearing groups. For all three of our voice-
722 hearing categories, the distinct contributions of predictive processing models to
723 mechanistic accounts remain to be specified. Such models may be particularly
724 valuable in determining the mechanistic roles of peripheral sensory deficits (such as
725 hearing loss) and social agent representation in everyday voice-hearing.
726 Another question concerns whether one would expect to see linear
727 associations between relevant cognitive mechanisms and phenomenological
728 features. Such linear associations might only be observed for particular mechanisms.
729 For example, the degree of bias in auditory signal detection could correlate in a linear
730 fashion with certain phenomenological variables, such as frequency or intensity,
731 whereas inhibition might covary non-linearly with those same phenomenological
732 variables.
733 An approach based on 'functional systems'[172] of dynamically interacting
734 cognitive, neural, and personal-sociocultural mechanisms will likely prove useful for
735 understanding complex patterns of interaction among a large number of constituent
736 processes and implicated mechanisms. Such an approach has, for example, been
737 proposed as a way of explaining how modality-general processes (such as source
738 monitoring) interact with modality-specific processes (such as inner speech) in
739 'networks of networks' that are differentially sensitive to disruption at different stages

of development[89]. Graph-theoretical and other approaches to understanding linkages among symptoms in psychopathology[173] might be valuable as research aims to elucidate the complex picture of voice-hearing across diagnostic groups. Although we have proposed our three-way categorization as a useful heuristic, future research should explore whether other taxonomies of voice-hearing may be more valuable in understanding phenomenology, mechanism, and targeting of treatment.

Progress in understanding voice-hearing will depend on the willingness of the research community to embrace principles of open, reproducible, replicable research. Voice-hearing research has previously relied on small sample sizes and non-standardized measures[174]. These factors likely account for inconsistencies in research findings that are apparent across the field. Initiatives that support large, pre-registered, multisite studies, such as the International Consortium on Hallucination Research[57], have the potential to counter some of the methodological problems that have plagued previous endeavors. As we look ahead to the next decade of research on this complex, heterogeneous, and profoundly personally significant experience, there are reasons to be hopeful that the rich and varied phenomenon of voice-hearing will continue to attract the attention of researchers, with the prospect of real benefits for those distressed by their experiences.

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Table 1. Perceptual-sensory, cognitive, and affective phenomenological features of clinical versus non-clinical voice-hearing

	Perceptual-sensory	***Cognitive***	***Affective***
Clinical	Frequency ↑	Perceived control ↓ Threat appraisals ↑	Content: Negative (critical/threatening) Emotional distress ↑ Functional interference ↑
Non-clinical	Frequency ↓	Perceived control ↑ Threat appraisals ↓	Content: Neutral/mundane Emotional distress ↓ Functional interference ↓
Shared features	Volume Clarity Number of voices Localization Linguistic complexity Form of address	Levels of conviction Beliefs regarding origin Interaction /compliance Personification of identity	

Note: Although affective features shared between clinical and non-clinical voice-hearing are ostensibly absent from the table, each individual's relationship with their voices tends to be complex and multi-faceted (for example, positive interactions in the context of seemingly hostile, pejorative voices), necessitating a nuanced and individualized approach.

Table 2. Summary of cognitive mechanisms underlying voice-hearing and associated experimental tasks.

Cognitive mechanism	Associated tasks	Hypothesized association with voice-hearing	Key findings
Source monitoring (also self-monitoring or reality monitoring).	Source memory: participants speak or hear a series of words, and must later recall which words were self-generated versus non-self-generated.	Voice-hearing individuals make more external misattributions, recalling self-generated words as non-self-generated.	Early studies showed an association between external misattributions and voice-hearing[54,55,158]; however, more recent studies have failed to replicate this finding[56,58].
Expectation/strong priors for speech	Auditory signal detection: participants listen to bursts of white noise, and are asked to respond whether speech was present or absent (see Figure 1).	Voice-hearing individuals make more false alarms (respond that they heard a voice when none was present), reflecting a bias towards detection of speech.	Early studies showed an association between an increase in false alarms and voice-hearing in psychosis and in the general population[62]. More recent work has replicated this finding, and shown a similar effect in non-clinical voice-hearers[58,175].
	Conditioned hallucinations: participants learn an association between a visual and an auditory stimulus, and later have to detect the auditory stimulus.	Voice-hearing individuals make more false alarms to the auditory stimulus when cued by the associated visual stimulus.	There is an association between conditioned hallucinations and voice-hearing in clinical and non-clinical groups, with no effect in non-voice-hearing psychosis patients[67].
	Sine-wave speech: participants listen to manipulated unrecognizable speech, and are asked to indicate whether speech is present or absent.	Voice-hearing individuals are better able to discriminate speech from non-speech.	There is some evidence that clinical and non-clinical voice-hearers detect more speech compared to healthy non-voice-hearing groups even before training via exposure to speech samples[53,68].
Memory inhibition	Intentional inhibition of currently irrelevant memories: in a continuous recognition paradigm participants are instructed to inhibit a response to a previously presented stimuli.	Voice-hearing individuals are less able to inhibit previously presented stimuli, and therefore make more errors in later task blocks.	There is evidence for an association between lower memory inhibition and voice-hearing in clinical groups[71] and in the general population[74]. However, another study did not observe this effect in a group of non-clinical voice-hearers[58].

Language lateralization, attentional control	Dichotic listening: participants are presented with conflicting auditory-verbal stimuli in each ear, and must report which stimuli they heard most clearly. In subsequent trials participants are instructed to attend to one ear at a time only.	Voice-hearing individuals show reduced right-ear correct responses compared to controls, and are less able to orient their attention when instructed.	There is evidence for reduced right-ear responses in clinical voice-hearers[162], but little evidence for this effect in non-clinical or everyday voices[58,176].

Box 1. Schizotypy and hallucination-proneness

Voice-hearing has typically been associated with a diagnosis of schizophrenia, which involves multiple positive symptoms (such as hallucinations, delusions, or disorganized speech) and negative symptoms (such as social anhedonia, that is, a disinterest in and a lack of pleasure from social situations) combined with a decreased level of functioning[177]. The constructs of schizotypy and hallucination-proneness were formulated to explore the distribution of traits that may underlie psychotic-like experiences in the general population, with the assumption that they share at least some components (phenomenological, etiological, or cognitive) with experiences reported by people with schizophrenia.

Schizotypy is generally posited as a set of personality characteristics or latent traits that vary across the population, are assumed to be relatively stable over time, and are possibly associated with an individual's liability to develop schizophrenia (or psychosis more broadly[151]). As such, schizotypy includes the propensity to experience perceptual aberrations, magical ideation, and social anhedonia, amongst other symptoms[178,179]. The construct of schizotypy encompasses, but is not specific to, voice-hearing. Although assessments of schizotypy include items relating to perceptual aberrations, these typically form their own factor in principal components analyses, indicating that this aspect of schizotypy is separately measurable and conceptually distinct from other facets, such as social anhedonia and cognitive disorganization[178,179].

The construct of hallucination-proneness, although strongly associated with schizotypy, attempts to assess trait-like variation in susceptibility to a broader range of perceptual experiences. The construct is more tightly focused on variation in hallucinatory experiences, and often breaks down into factors associated with specific sensory modalities (for example, auditory, visual, and tactile)[180–182].

The term ‘hallucination’ has itself been the subject of debate, and typically includes perceptual experiences that occur in the absence of external stimulation; have a compelling sense of reality; are not amenable to voluntary control; and occur in the awake state[183,184]. However, some experiences typically labelled as hallucinations do not meet all of these criteria, such as experiences triggered by external sensory stimulation (for example, hearing a voice directed at oneself in a noisy crowded room[185]), and hallucinations that occur as a person is on the borders of sleep[28]. In this Review our focus is on voice-hearing experiences that, whether or not meeting the full definition of hallucination, are crucial to understanding the phenomenology and mechanisms involved in such experiences.

Box 2. Case examples of everyday, non-clinical and clinical voice-hearing

Here we provide illustrative case examples of everyday, non-clinical, and clinical voice-hearing. These specific examples should not be taken to suggest that all voice-hearing within these groups can be explained in the same way, or that specific individuals only ever have experiences associated with one of these groups.

[H1] Everyday voice-hearing

Our case of everyday voice-hearing involves a recently bereaved older person. They expect to hear the voice of the deceased partner (strong prior), which lowers the threshold for non-veridical perceptions. Voice-hearing is intensified by vivid mental imagery, personality traits such as absorption, and sensory deprivation due to social isolation. Active social representations arise from the manifestation of a known, personified agent. Phenomenologically, the single voice has a specified gender and identity, is experienced with a high degree of clarity, and is localized externally within familiar environs. The origins of the voice are well understood, and its content is mostly positive or neutral.

[H1] Non-clinical voice-hearing

Our case of non-clinical voice-hearing involves to a spiritualist who holds particular religious beliefs and who regularly engages in the cultivated practice of seeking out voices. They expect to hear one or more voices, with increased susceptibility conferred by spontaneous hyperactivity within the auditory cortex[91]. They have personality traits related to elevated openness to experiences, and active social agent representations take the form of known spiritual identities recognized within the specific subculture. The active pursuit of voices transpires via an altered dissociative state, which at times is aided by the deliberate consumption of psychoactive stimulants. Phenomenologically, these voices take place with high frequency,

typically when they are sought out. Beliefs regarding the voices' origins predominantly involve cultural and spiritual interpretations, with personification aligned to culturally sanctioned figures or spirits. Controllability is desired, and is variable, but typically improves with practice.

[H1] Clinical voice-hearing

Our case of clinical voice-hearing involves an individual experiencing psychosis. In addition to mechanisms that also underlie non-clinical voices (dominance of speech priors, auditory cortex hyperactivity, dissociative experiences, social agent representation, and personality traits, in this case heightened schizotypy), further mechanisms significantly alter the nature of voice-hearing experiences. Cognitive processes encompass diminished inhibition of irrelevant stimuli, alongside source-monitoring difficulties. Neural mechanisms include fronto-temporal dysconnectivity and elevated dopamine. These influences are further exacerbated by a history of childhood trauma and existing sleep disruptions. Phenomenologically, they frequently experience voices that cannot be controlled, with a prolonged duration per episode, and typically in third-person address. They have a strong conviction that voices are real and tend to comply with command hallucinations. Voices are generally experienced as intrusive, and are associated with a designated purpose. Valence of content is mixed, but is often negative, involving critical or derogatory themes. Emotional distress and functional interference are significant, and are accompanied by bodily sensations, such as temperature changes or tingling.

Box 3. Hallucinations beyond the auditory

The fact that many voice-hearing experiences do not carry a strong auditory component has triggered growing interest in experiences in modalities beyond the auditory. Up to 14 sensory modes have been proposed, each with their own corresponding type of hallucination[12]. Psychosis studies have disproportionately focused on voices, with a limited subset of research exploring visual, olfactory, and somatic-tactile domains. One study noted that lifetime prevalence of hallucinations in two or more senses was double the prevalence of hallucinations in only a single modality[186]. Emerging evidence has also suggested that specific patterns of clustering by sensory domain may occur[187–189]. Hallucinations in other modalities were twice as likely in people hearing voices, whereas this likelihood was more than 11 times higher in those who experience visual hallucinations[189]. Voice-hearing co-occurs with visual hallucinations, while the latter tend instead to cluster with olfactory and somatic-tactile experiences[187]. In general, experiencing hallucinations in more than one modality is associated with more severe psychopathology and less favorable outcomes[190]. General population studies have also reported multisensory hallucinations, involving hallucinatory experiences across two or more sensory modalities, with heightened variability in sensory involvement that tends to stabilize with age[191]. Multiple modalities of hallucination might be associated with more severe voice-hearing and poorer mental health in non-clinical groups[192].

Additional consideration needs to be given to the special case of multimodal hallucinations (as distinct from multisensory hallucinations), where there are known overlaps in time order and/or thematic content of hallucinatory experiences[193,194]. The auditory-visual-tactile combination might be most prevalent in psychosis[195], with serial, rather than simultaneous, experiences more common[196]. Auditory-visual hallucinations are additionally associated with elevated delusionality and negative affect[197]. Some authors have speculated that multimodal hallucinations engender

higher levels of conviction and distress due to greater veracity afforded by simultaneous multisensory involvement[9,195]. However, much remains unknown, including whether multisensory hallucinations are widely shared with non-clinical and everyday voice-hearers, and more importantly, possible therapeutic implications, given the hypothesized elevation in distress.

Emerging evidence suggests that multisensory hallucinations might have links to sociocultural precipitants: more traumatic events correlate with more modalities involved in subsequent hallucinations[198–200]. This growth of interest in modalities beyond the auditory has led to an approach to understanding hallucinations in any particular modality as representing combinations of modality-general mechanisms, such as source-monitoring processes or social agent representations, and modality-specific mechanisms, such as processes relating to peripheral sensory systems[89].

Experiences in other sensory modes (including gustatory, sensed presence, kinesthetic-vestibular, and autoscopic) and hypnagogic-hypnopompic hallucinations[201] have been less studied, although we do know they are experienced by the general population[191,202].

Figure legends

Figure 1. Auditory signal detection tasks.

(A) In an auditory signal detection task[62] participants listen to short bursts of white noise through headphones (panels 1–3). In some trials, a speech stimulus is presented at a threshold level (panel 2). The participant is instructed to respond, with a button press, as to whether they think a voice was present in the noise or not (panel 4). (B) Everyday, non-clinical, and clinical voices are associated with biased performance towards endorsing that a voice was present (that is, a reduced response criterion; red line) compared to non-voice hearers (gray line). This results in more hits (correctly responding that a voice was present) and more false alarms (responding that a voice was present when it was not). Evidence is mixed regarding whether disproportionately high false alarm rates in voice-hearers are also caused by reduced sensitivity (ability to perceptually differentiate voice signals (blue curve) from noise (yellow curve).

Figure 2. Varieties of continuum models.

Intensity of experience in individuals who do not hear voices, clinical voice-hearing, and clinical voice hearing (y-axis represents variation in level of need for care, distress, or psychotic experiences). (A) Diagnostic discontinuous model in which non-clinical voice-hearing is only explicable in terms of benign experiences and processes that also occur in non-voice-hearers and do not necessitate clinical treatment (blue). Distressing experiences (yellow) uniquely characterize clinical voice-hearing. (B) Continuous model in which non-clinical voice-hearing represents an attenuated version of psychotic experience (pink), fundamentally of the same kind as in clinical voice-hearing, and in which the frequency or intensity of psychotic experience is directly related to distress and the need for clinical treatment. (C)

Continuous model in which psychotic experiences occur independently of the distress and the need for treatment that characterizes clinical versus non-clinical voice-hearing. Adapted from ref[14], CC BY 4.0.

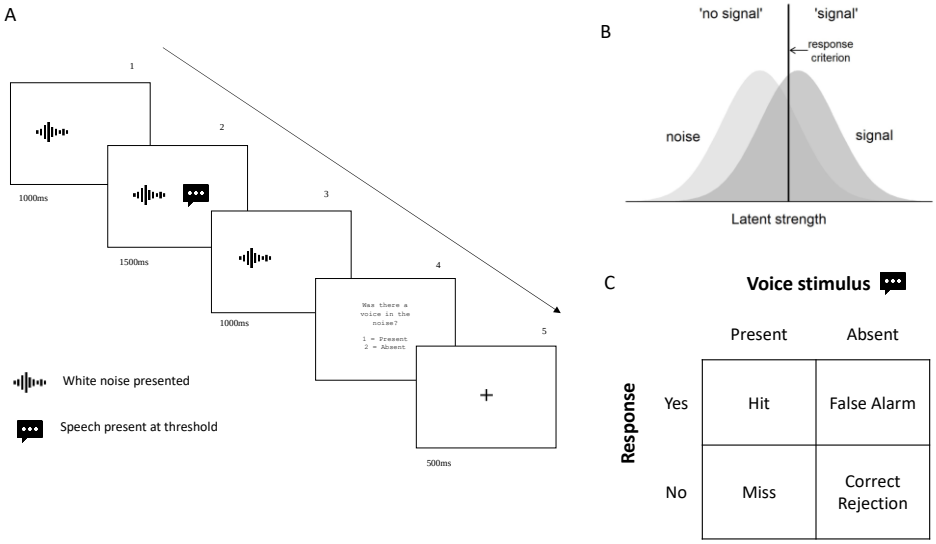
Glossary

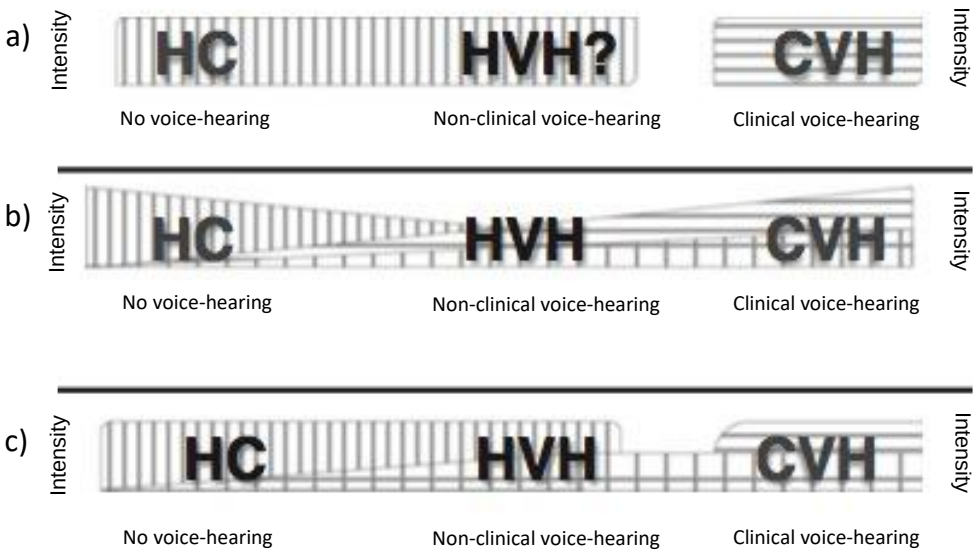
Autoscopic: The psychic duplication of a part or whole of one's body in external space, or in other words, an out-of-body experience.

Default mode network: A network of brain regions showing significant activation when the participant is not engaged in any task, thought to be related to self-referential processing.

Functional connectivity: A measure of the temporal correlation of activity in different brain regions.

Structural connectivity: A group of measures of how much different parts of the brain are anatomically connected.


A
1
2
3
4
5
1000ms
1500ms
1000ms
Was there a voice in the noise?
1 = Present
2 = Absent
500ms
White noise presented
Speech present at threshold
B
'no signal'
'signal'
response criterion
noise
signal
Latent strength
C
Voice stimulus
Present
Absent
Response
Yes
No
Hit
False Alarm
Miss
Correct Rejection


a)
Intensity
HC
HVH?
CVH
Intensity
No voice-hearing
Non-clinical voice-hearing
Clinical voice-hearing
b)
Intensity
HC
HVH
CVH
Intensity
No voice-hearing
Non-clinical voice-hearing
Clinical voice-hearing
c)
Intensity
HC
HVH
CVH
Intensity
No voice-hearing
Non-clinical voice-hearing
Clinical voice-hearing