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# Some Varieties of Spatial Hearing<sup>1</sup>

ROBERTO CASATI AND JÉRÔME DOKIC

### I. Introduction

A principle of classification of metaphysical theories of sounds can be based on the alleged location each theory assigns to sounds. Sounds can be said to be located either where their material sources are (giving rise to a family of *distal theories*), or where the hearer is (*proximal theories*), or somewhere in between (*medial theories*). In Casati and Dokic (1994, 2005), we argued that a major shortcoming of proximal and medial theories, as opposed to distal theories, is that they do not locate sounds where an untutored description of what is heard suggests they are, namely at their sources. As a consequence, these theories face the obligation of providing an explanation of why auditory perception allows for such a massive error. Then, confident that we stood on phenomenology's side, we put forward our own version of a distal theory, the Located Event Theory, according to which sounds are physical events located (and normally heard as located) where their sources are.

Of course this principle of classification leaves out other theories, in particular what we may dub '*a-spatial theories*'. According to a-spatial theories of *sounds*, sounds do not really have locations in physical space. They are neither individuated in spatial terms nor located anywhere. A-spatial theories of sounds are neither distal nor proximal nor medial, since they invite us to deny that sounds are spatially located entities in the first place. At first sight, our phenomenological argument is still valid against these theories. For doesn't one usually *seem* to hear sounds to be located somewhere in space, namely at their sources? Again, a-spatial theories seem to be saddled with a commitment to an error theory of auditory perception.

<sup>1</sup> Research for this chapter was partly funded by the European Commission, Sixth PCRD Network of Excellence 'Enactive Interfaces', IST-2002-002114.

However, consider a-spatial theories of *auditory perception*. The claim here is not that sounds are non-spatial, but that one does not really *hear* them to be located anywhere. The only things that the hearer can locate on the basis of her auditory perception are not the sounds themselves, but (at best) their sources; she hears the trumpet, rather than the sounds it makes, to be located somewhere in the distance. A-spatial theories of auditory perception are in principle independent from a-spatial theories of sounds. For instance, one may argue that sounds themselves are not heard to be located even though they actually are somewhere in physical space.

A-spatial theories of auditory perception threaten our phenomenological argument against proximal, medial, and a-spatial theories of sounds. For if one does not hear sounds to be located anywhere, auditory experience is *neutral*—rather than massively in error—as far as the locations of sounds are concerned.

In what follows, we provide some meta-theoretical constraints for the evaluation of a-spatial theories of sounds and auditory perception. We shall point out some forms of spatial content auditory experience can have. Our tentative conclusion is that if auditory experience does not necessarily have a rich *egocentric* spatial content (the kind of content that enables the hearer to locate sources in her egocentric space—for instance, to the left and far away), it must have *some* spatial content for the relevant mode of perception to be recognizably auditory. An auditory experience devoid of any spatial content, if the notion makes sense at all, would be very different from the auditory experiences we actually enjoy. This is enough to dismiss current a-spatial theories of auditory perception. As a consequence, our initial taxonomy of proximal, medial, and distal theories, as well as our phenomenological argument in favor of distal theories, are still topical.

## 2. The Located Event Theory

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Let's start with articulating our own view, the Located Event Theory.<sup>2</sup> According to this view, sounds are monadic events happening to material objects. This means that sounds are *located at their sources*, and are identical with, or at least supervene on, the relevant physical processes in them. This in turn means that:

<sup>2</sup> This section elaborates on part of Casati and Dokic (2005).

- (i) The relevant physical processes in the sounding object do not move any more than sounds appear to.
- (ii) They do not propagate from the object, just as sounds do not appear to.
- (iii) Like sounds, and unlike sound waves in the ambient medium, their intensity can remain the same through a period of time, even if one distances oneself from the source and hence hears them as less loud.
- (iv) Finally, tuning forks and other sounding objects can be taken as continuing to vibrate irrespective of their being or not being immersed in a medium. We do not create sounds by surrounding vibrating objects with a medium (for instance, air)—we simply *reveal* them.

These four features of sounds construed as located events are in agreement with the phenomenological description of sounds.

Prima-facie objections to the Located Event Theory tend to either misconstrue the phenomenology or beg the question against the idea that sounds are located. For instance, it may be argued that echoes provide a counter-example to the Located Event Theory insofar as the sound as located event is not where phenomenology has it. However, this is a clear case of misrepresentation, comparable to that of seeing an object in a mirror. Missing this fact would lead right into Hobbes's sophism (Hobbes 1651/1839: I, I) that colors are not in things because we can 'sever' them from things by using a mirror, which, generalized, leads to the awkward idea that material objects are not where we see them.

Another alleged problem for the Located Event View is the fact that many features of sounds as they are heard are explained by medial or proximal properties, not by distal properties. This is for instance said to be the case with the Doppler Effect. However, the Located Event View is able to claim that when we experience the Doppler Effect, we just hear the sound in the sounding object, whose features are distorted by the particular experiential situation (relative movement of the sounding object and the hearer).

Furthermore, the Located Event Theory does not make sound perception impossible. Auditory perception of sounds requires a medium which transmits information from the vibrating object to the ears; however, what occurs in the transmitting medium is not constitutive of sounds. One may consider a simple analogy with light. Light is causally responsible for the perception of an object's surface. But this does entail that light itself is seen. The same, according to the Located Event Theory, holds for medial sound waves. Medial sound waves are

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necessary for perception, but what is perceived is not those waves, but distal sounds.

Finally, one may consider alternative phenomenological descriptions that appear to be more in line with either proximal or medial theories of sound. One may claim that the impression of having a sound in one's ear (purely subjective sound) is enough to favor a proximal description. More interestingly, one may want to put some weight on the alleged meaningful use of expressions such as 'the sound fills the room', and 'sounds fill the room', which appear to speak in favor of an alignment of phenomenology on the medial conception. But we just question the fact that this is an adequate phenomenological description; it may be simply the projection of a true epistemological claim (the fact that the sound is reckoned to be audible from any place in the room) onto a false claim about perceptual content. In this respect sounds are unlike fog, which can literally be seen to fill a room.

### 3. Assessing the Located Event Theory

We think that the Located Event Theory is superior to its competitors among distal theories. One such competitor is the Relational Event Theory propounded by O'Callaghan (Chapter 2; 2002, 2007), which claims that sounds are events involving both the source and the surrounding medium. They are relational rather than monadic events.

The Relational Event Theory appears to rely upon an argument from vacuums; that is, the fact that sounds are not heard in a vacuum. Of course the Located Event Theory is not affected by a metaphysical reading of this claim, as it does recognize that medial waves are necessary for hearing—if you put a bell in a vacuum jar as the bell goes on vibrating, the sound is still present, although it is not heard. On the other hand, we find the phenomenological reading of this claim questionable in the light of the existence of auditory analogs of tunnel effects, in which unheard items can be still perceptually present. If you could instantaneously empty and refill the vacuum jar in swift alternation, you would hear the sound of the vibrating bell not as going in and out of existence, but simply as not being audible.

We discussed the relative merits of the varieties of distal theories in Casati and Dokic (2005). At this stage, it looks as if the Located Event Theory is a simpler theory which does more justice to the representational power of auditory perception. Let's now see how the Located Event Theory fares with respect to a-spatial theories of sounds and auditory perception.

#### 4. Strawson's Thought-Experiment

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A-spatial views of sounds, in more or less strong versions, are widespread in the psychological and philosophical literature.<sup>3</sup> These views often lead to a-spatial theories of auditory perception. For instance, Strawson's famous thought-experiment of a no-space world whose inhabitant's only sensory modality is auditory is motivated by the claim that sounds are intrinsically non-spatial. Here is what he writes:

Where experience is supposed to be exclusively auditory in character, there would be no place for spatial concepts ... Sounds ... have no intrinsic spatial characteristics: such expressions as 'to the left of', 'spatially above', 'nearer', 'farther', have no intrinsic auditory significance ... A purely auditory concept of space ... is an impossibility. The fact that, with the variegated types of sense-experience which we in fact have, we can, as we say, 'on the strength of hearing alone' assign directions and distances to sounds, and things that emit or cause them, counts against this not at all. For this fact is sufficiently explained by the existence of correlations between the variations of which sound is intrinsically capable and other non-auditory features of sense-experience. (Strawson 1959: 65–6)

This passage involves two distinct claims: a *metaphysical* claim according to which sounds are not spatial entities, and an *epistemic* claim according to which there can be auditory experiences devoid of any spatial content. The former claim leads to the latter in the sense that if one wants to avoid an error theory of auditory experience, one must explain away the spatial content of such experience. According to Strawson, the spatial content of *ordinary* auditory experience is fixed by non-auditory features of sensory experience. A *purely* auditory experience, by contrast, would not be one in which sounds would appear to be located in egocentric space.

Given the essential multimodal nature of perception, the notion of a purely auditory experience is suspect. The spatial content of normal auditory perception arguably depends on other senses. It also depends on intentional action, not least because locations in egocentric space are also locations in behavioral space (Evans 1986). However, it is plausible that the dependence among audition, other sensory modalities, and action is constitutive rather than just causal. In this case, if auditory experience is intrinsically spatial, it is not clear that Strawson avoids an error theory after all.

It might be objected that we should interpret Strawson as trying to ground the metaphysical claim on the epistemic claim, rather than the other way

<sup>3</sup> Discussed among others by authors like Lotze, Binet, Heymans, Stumpf, Wellek, Révész, Strawson, and Evans. See Casati and Dokic (2005).

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round. However, as with all thought-experiments, we should be cautious in moving from an epistemic possibility to a metaphysical possibility.

Let's accept that one can hear distinct sounds even when one does not know where they are in space relative to each other or relative to oneself (this is also true in some pathological cases, as we shall show later). For instance, if one hears certain types of sounds underwater, one has the impression of perceiving sounds without definite spatial localization (aural disparity is insufficient for spatial discrimination, as sound travels at about 1500 m/s in water, more than four times faster than in air, and as our hearing is adaptively tuned to air). Underwater sounds appear to 'just happen', without being heard as being anywhere. The behavioral response witnesses this. One does not spontaneously turn one's head towards the source. All one can do, in order to find the source, is to randomly move around, trying to detect differences in intensity, so as to incrementally approach the source.

The fact that we can imagine a non-spatial auditory experience does not immediately justify the conclusion that there can be a world exclusively populated with sounds, here construed as entities without any spatial structure. Here are more focused formulations of the relevant claims:

1. I imagine hearing sounds independently of an egocentric representation of where they come from (epistemic claim).
2. I imagine hearing non-located sounds (sounds which in fact are not located in space) (metaphysical claim).

Phenomenology justifies at best the first claim, and further argument is needed to deduce the second claim. One cannot directly infer, from the fact that we can perceptually represent a sound without representing its location, that we can perceptually represent a non-located sound.

### 5. O'Shaughnessy's View

Strawson's contention is that we can *imagine* non-spatial auditory experiences. This is compatible with the claim that at least *some* auditory experiences represent sounds as being located in space (as he himself acknowledges in the quoted passage). Other philosophers have gone further and rejected even this claim. O'Shaughnessy writes:

Thus, hearing a sound to be coming from point  $p$  is not a case of hearing it to be *at*  $p$ . This is because the sound that I hear is *where I am* when I hear it. Yet this latter fact is liable to elude us because, while we have the auditory experience of hearing

that a sound *comes from*  $p$ , we do not have any experience that it is here where it now sounds. (Rather, we work that one out.) And this is so for a very interesting reason: namely, that we absolutely never immediately perceive sounds to be *at* any place. (O'Shaughnessy 2000: 446; emphasis in original)

Here, O'Shaughnessy makes a positive and a negative claim. The positive claim is that we normally hear sounds to be *coming* from a particular place. The negative claim is that we do not hear sounds to *be* at any place.

In our terminology, O'Shaughnessy endorses a *proximal* theory of sounds. First, sounds are metaphysically dependent on the hearer. As such, their location can only be that of the hearer herself: 'the sound that I hear is *where I am* when I hear it'. Second, an error theory of auditory perception is avoided because the spatial content of audition is explained by the fact that we hear *sources* (and not sounds) to be located in space. (Surely we can hear moving objects. If, as some have claimed, events cannot move and sounds are events, the objects we hear as moving cannot be sounds; they must be space-occupying, material objects.) Matthew Nudds (Chapter 4) endorses O'Shaughnessy's point, suggesting that we explain away the putative examples in which one is tempted to say that one hears sounds as located as really cases in which one hears the location of the sources of the sounds.

Let's take stock. Strawson defends an a-spatial theory of both sounds and auditory perception. O'Shaughnessy favors an a-spatial theory of auditory perception (with respect to sounds), but rejects the non-spatiality of sounds.

Strikingly, both Strawson's and O'Shaughnessy's arguments against spatial theories of auditory perception concern the *egocentric* spatial content of auditory experience, namely the kind of content which enables the hearer to locate entities relative to her (to the left, to the right, above, below, in front, or behind). However, auditory perception can have various forms of *non-egocentric* spatial contents. These must be taken into account in fully evaluating the prospects of a-spatial theories of auditory perception.

In what follows, we shall discuss two forms of non-egocentric spatial content. Auditory perception can be said to have non-egocentric spatial content insofar as it represents (i) material sources of sounds as having spatial properties, and (ii) sources and sounds as being spatially distinct entities.

## 6. Hearing Sources

Auditory perception can give one access to the spatial structure of the world even if it does not have an egocentric spatial content. One can auditorily



perceive the constituting *matter* as well as the *internal structure* of sources, whether or not one is able to locate them relative to oneself (think again of the underwater perception; you may not be able to tell where it is relative to you, but you know there is an approaching *boat engine*). One can know just by hearing that an object is hollow, or that it is composed of several interconnected parts. (Think of shaking a closed box containing various tiny objects.) In such cases, one perceives with one's ears various ways in which material objects take up space.

There is a venerable view according to which the primary object of auditory perception is always the sound, and we perceive at best indirectly its source as a space-occupying entity. For instance, Berkeley wrote in his *Three Dialogues between Hylas and Philonous* that 'when I hear a coach drive along the streets, immediately I perceive only the sound, but from experience I have had that such a sound is connected with a coach, I am said to hear the coach' (1948–57: 204). On this view, the perception of the source would be necessarily *epistemic* in Dretske's (1981) sense. We can hear the sound produced by a car, but we cannot hear the car itself. At best, we can hear *that* the car is humming.

As an alternative to the venerable view, consider the hypothesis that perception of sounds is always perception of dynamic states of affairs involving sounds *and* sources. On this hypothesis, sources are as much primary objects of perception as sounds themselves.

Two remarks about the alternative view are in order. First, the view does not entail that one is always able to *recognize* the source on the basis of hearing the sounds it produces. Perhaps one can only think of the source in *demonstrative* terms, such as 'that noisy thing'. Abstract electronic music is an interesting case in point. When listening to this kind of music, one may have no idea of what is producing the sounds one hears—except perhaps loud-speakers.

Second, the 'sources' that we hear are not always concrete, mesoscopic objects.<sup>4</sup> When we hear thunder, for instance, we do not perceive any such object. Still, our auditory perception is about a mass of material molecules involved in a complex vibrating event which either is or constitutes the sound we hear.

Nudds (Chapter 4) acknowledges that auditory perception represents material sources and some of their (static and dynamic) properties. He observes that auditory perception has a *dual* content: one hears material objects *as* the sources of the sounds one also hears. Nevertheless, Nudds refrains from identifying these sounds with the events happening to or within the sounding objects: he

<sup>4</sup> Meaning objects that are cohesive, bounded, three-dimensional, and move as a whole. For references and a critical discussion of the role of objects in cognition, see Casati (2003).

writes, ‘the sounds we experience normally correspond to their sources—to the things that produced them’ (xx). The sound one hears when a bell is struck is distinct from the vibrating event happening to the bell. We do not wish to go into the details of Nudds’s argument here, but let us make two observations relevant to the evaluation of the Located Event Theory.

First, the Located Event Theory is about the personal level of auditory experience. As such, it is of course compatible with the sub-personal-level claim that information about the object can be extracted directly from properties of the *sound wave* by a process that involves auditory grouping, no part of which requires the auditory system to represent how the *object* is actually vibrating.

Second, Nudds makes much of the possibility that our experience of sounds is veridical even when those sounds do not correspond to their sources. This possibility does not entail that sounds can in fact be detached from their sources. Again, when hearing sounds produced by loudspeakers, one has a perfectly veridical experience as far as the most basic content of experience is concerned—one may just not hear these sounds *as* being produced by loudspeakers. The illusion discussed by Nudds, in which one seems to hear a single sound that is in fact produced by two sources, is more complex. Suffice it to say that it is consistent with the Located Event Theory to claim that in such a case, one’s auditory experience is at least partly veridical: one hears audible events located in a more or less definite direction. One has a veridical auditory experience to the effect that something is happening there. After all, one is *surprised* when one finds out which objects are causing our auditory experience, and how. One is indeed fooled about the number of objects and events involved, but one’s auditory experience still correctly represents that something audible was going on around there.

## 7. Hearing Distinctively

The ability to perceive distinct or segregated sounds and sound sequences is known as ‘auditory streaming’. Possession of this ability is essential to following a conversation involving several people. It is also involved in the so-called ‘cocktail party effect’ (Cherry 1953)—the sudden capture of one’s attention by a familiar noise in an auditorily clogged environment.

There are pathological cases in which patients lack this ability because their brain cannot process relevant spatial information about sounds. We can describe these cases using the distinction between a ‘what’ system and a ‘where’ system underlying auditory experience at the sub-personal level.

The what/where distinction is borrowed from vision science. As is now well known, psychophysical, functional, and anatomical considerations suggest that visual information from the visual cortex follows two distinct pathways: a ventral pathway and a dorsal pathway. The ventral pathway carries information about *what* object there is to be seen, whereas the dorsal pathway carries information about *where* the object is in egocentric space. One of the arguments in favor of this divided architecture is the existence of *double dissociations*: in pathological cases, there can be what without where (*visual disorientation*) and where without what (*visual agnosia*).<sup>5</sup>

[FN:5]

In the auditory case, similar double dissociations have been documented. In pathological cases, there can be *what* without *where* (*spatial deafness*) and *where* without *what* (*auditory agnosia*). In the latter case, the patient is unable to recognize sounds but can locate them in egocentric space. In the former case, the patient recognizes sounds (acoustic and semantic recognition is preserved) but is unable to locate them in egocentric space. Spatial deafness should be distinguished from ‘deaf hearing’, which is the analogue of the phenomenon of ‘blindsight’ in the visual case. Patients with spatial deafness, unlike those with deaf hearing, have conscious experiences of sounds.<sup>6</sup>

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Interestingly, patients with spatial deafness often complain about noisy environments, because for them sounds tend to merge in a cacophony. This suggests that spatial deafness is accompanied by a failure to segregate sounds.

However, this is an oversimplification. There are rare cases of spatial deafness in which subjects have a preserved ability to hear distinct sounds. The patient studied by Bellmann and Clarke (2003) is unable to localize stationary sounds in egocentric space, and to hear sound sources as moving. Still, unlike other spatially deaf patients, she has a preserved ability to segregate sounds and sound sequences.

One experiment which reveals this exploits the ‘masking phenomenon’ according to which a soft sound (for instance, a tawny owl) disappears if a louder sound of similar frequency range (for instance, a helicopter sound) is presented simultaneously. Of course, the more the sounds are spatially separated, the more clearly they are perceived as two distinct sounds. In the experiment, the owl sound is presented as a target in front of the subject and the masking, and the helicopter sound is presented at various positions relative to it. The subject, who cannot perceive the apparent motion of the masking sound, is instructed to test whether the target is present or not. When the two sounds have different virtual locations, she reports hearing two spatially

<sup>5</sup> See Ungerleider and Mishkin (1982), Goodale and Milner (1992).

<sup>6</sup> See Clarke *et al.* (2002).

superimposed sounds, and when they have the same location, she reports hearing just the masking sound.

Bellmann and Clarke (2003) hypothesize that the patient implicitly uses *spatial* cues (in the case in point, inter-aural time differences) to segregate simultaneous sound sources. Thus spatial processing would have at least two functions: localization (the ‘where’ system) and facilitation of perception (performed as part of the ‘what’ system).

We can try to imagine what it is like for this patient to have auditory experiences. She is unable to locate the sounds she hears relative to each other or relative to her. As far as the egocentric content of her experience is concerned, her situation is somewhat analogous to that (described in an earlier section) in which a normal subject hears sounds underwater. However, perhaps in contrast to the latter situation, she is able to hear several *distinct* sounds simultaneously. Contrary to other patients with spatial deafness, she does not seem to be bothered by noisy environments (she works in a popular supermarket).<sup>7</sup>

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The forgoing discussion suggests that the ability to perceive *distinct* sounds or sound sequences is at bottom a *spatial* ability. This is relevant to the interpretation of Strawson-like thought-experiments. When we imagine having an auditory experience devoid of egocentric spatial content, we can still imagine hearing distinct sounds simultaneously. For instance, we do not want Strawson’s Master Sound (the accompanying sound to every experience in Strawson’s thought-experiment) to mask the particular sounds to be heard at the ‘places’ it embodies. However, given the spatial nature of auditory streaming, it follows that the sounds themselves that are imagined are spatial, or spatially linked to material sound sources, whether they are represented as such or not.

But is auditory experience of distinctness entirely devoid of spatial content? Consider again the sounds to be heard underwater. Their experienced spatial location is not definite. This can mean either of two things. The first possibility is that sounds are heard as completely *non-spatial*. The second is that sounds are heard as being *somewhere*, but that there is no specific location at which they are heard as located.

Now consider the case in which a subject non-egocentrically but distinctively hears two simultaneous sounds. Our suggestion is that the subject’s auditory experience has a minimal spatial content: she hears two sources as being spatially separate. Of course, such content is *topological* rather than metrical; she cannot

<sup>7</sup> There are here intriguing questions which, as far as we know, are not addressed in the relevant publications, for instance: Can the patient enjoy music? Can she hear multiple sounds as chords?

tell, on the basis of her auditory experience, *how far* the sources are located relative to themselves and relative to her. Still, she can tell that they are not at overlapping, hence connected, locations—she has some spatial information about material objects producing sounds in the spatial world. Hearing distinct sounds and sources is hearing them as having distinct spatial locations, where of course what counts as distinct locations depends on the hearer’s auditory acuity.

## 8. Conclusions

Egocentric spatial content is not the only form of spatial content auditory perception can have. One can hear the material sources of sounds occupying space in many different ways, and one can hear sounds and sources as having distinct positions in space, even if one does not perceive what spatial relation one bears to these objects. (In fact, we may speculate that construing all spatial content as being ultimately egocentric is a prejudice of the post-Kantian, phenomenological tradition.)

What is the relevance of these claims to the evaluation of a-spatial theories of sounds and auditory perception? Well, first of all, the possibility of imagining having (or, for that matter, just having) an auditory experience devoid of spatial egocentric content does not show that such experience is intrinsically non-spatial. In fact, it is quite difficult if not impossible to imagine having a recognizably auditory experience which has no spatial significance whatsoever. At the very least, a convincing a-spatial theory of auditory perception is still forthcoming.

Another point concerns a-spatial theories of sounds. Let’s suppose, for the sake of argument, that sounds do not have spatial locations. Can one then maintain the claim that auditory perception is intrinsically spatial, at least in the non-egocentric ways we have tried to highlight above? More precisely, can one avoid an error theory of auditory perception? The only way to avoid postulating massive error would be to argue that the spatial content of auditory perception concerns material sources rather than sounds. After all, in the relevant cases, sources are what we hear as occupying space or as being distinct objects. We do not think that this is a promising way. When one hears sources as occupying space, one perceives that something happens to and within them, and we see no reason not to identify (at least aspects of) these happenings with sounds. Similarly, when we hear two distinct sources, we also hear two distinct sounds. Sounds *and* sources are heard as having some spatial separation. Once again, we do not see any mystery here: sounds are physical

events happening to sources, and the spatial locations of the former depend on the spatial locations of the latter. The Located Event Theory still appears to be the best explanation of these phenomena.

It follows that a-spatial theories of sounds are committed to an error theory of auditory perception even if egocentric spatial content is ignored. Sounds must be located somewhere if auditory perception is intrinsically spatial. Note that our initial appeal to phenomenology is still valid: sometimes (if not most of the time), one hears sounds to be located at their sources. There is no reason to think that egocentric spatial content is less veridical than non-egocentric spatial content. (In general, egocentric spatial content is not essentially different from non-egocentric spatial content. Egocentric spatial content locates the objects of perception with respect to the perceiver, which is of course necessary if perceptual experience is to play a role in orienting action, but the same kind of spatial relations are represented in both cases.) Unless one shoulders an error theory of auditory perception, we maintain that phenomenology favors distal theories over proximal and medial theories of sounds.

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