

Original citation:

Nudds, Matthew. (2014) Auditory appearances. *Ratio*, 27 (4). pp. 462-482. ISSN 0034-0006

Permanent WRAP URL:

<http://wrap.warwick.ac.uk/75761>

Copyright and reuse:

The Warwick Research Archive Portal (WRAP) makes this work by researchers of the University of Warwick available open access under the following conditions. Copyright © and all moral rights to the version of the paper presented here belong to the individual author(s) and/or other copyright owners. To the extent reasonable and practicable the material made available in WRAP has been checked for eligibility before being made available.

Copies of full items can be used for personal research or study, educational, or not-for-profit purposes without prior permission or charge. Provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way.

Publisher's statement:

"This is the peer reviewed version of the following article Nudds, Matthew (2014) Auditory Appearances. *Ratio*, 27 (4). pp. 462-482, doi: 10.1111/rati.12083 has been published in final form at <http://dx.doi.org/10.1111/rati.12083>

This article may be used for non-commercial purposes in accordance with Wiley Terms and Conditions for SelfArchiving."

A note on versions:

The version presented here may differ from the published version or, version of record, if you wish to cite this item you are advised to consult the publisher's version. Please see the 'permanent WRAP URL' above for details on accessing the published version and note that access may require a subscription.

For more information, please contact the WRAP Team at: wrap@warwick.ac.uk

AUDITORY APPEARANCES

Matthew Nudds

Abstract

It might be suggested that in auditory experience elements of the material world are not apparent to us in the way they are in vision and touch, and that this constitutes a shortcoming in the kind of cognitive contact with the world provided by auditory perception. I develop this suggestion, and then set out a way of thinking about the appearances of sound-producing events that might provide a response.¹

We hear sounds. Many of the sounds we hear are produced by things happening in the world around us. Hearing the sounds produced by things happening often puts us in a position to recognise those things. The following are some mundane examples:

a bottle being uncorked
a match being struck and igniting
someone screwing up a sheet of paper into a ball
the opening of a Zippo lighter
a cigarette lighter being lit
winding an old clock
zipping up a zip

These are examples of different kinds of sound-producing event. If you were to hear the sound made by one of these events, the chances are that you would be able to recognise what kind of event it was.

In the first half of this paper I ask how we recognise these events, and whether our capacity to do so exploits the same kind of cognitive contact with the material world that is provided by vision and touch. For as long as we are not subject to illusion or other sensory malfunction it is possible to acquire knowledge of the material world solely on the basis of vision or touch. There is

¹ Thanks to James Stazicker for very helpful comments and suggestions.

a worry that the same is not true of auditory perception. At best, it might be said, auditory perception grounds knowledge of sounds; knowledge of the world depends on non-auditory knowledge of the contingent connection between sounds and what produces them. I begin by setting out this line of thought in more detail, and outlining a response to it. I then suggest that there is a second kind of worry: that elements of the material world are not apparent to us in auditory experience in the way they are in visual and tactile experience, and that this constitutes a shortcoming in the kind of cognitive contact with the world provided by auditory experience. Finally, I set out a way of thinking about our perception of sound-producing events that might provide a way to respond to this worry.

Sounds are the sensory objects of our auditory experience, in the following sense. Sounds are things that we can pick out and attend to in auditory experience, and they are what determine the conscious character of auditory experience: they are auditory objects of awareness. Sameness and difference in auditory experiences is a matter of sameness and difference in the sounds the experiences are of. There are no objects of auditory experience other than sounds whose presence can make a difference to the conscious character of auditory experiences. It may be that two auditory experiences can differ in their conscious character without any difference in the sounds they are of but, if so, such a difference is due to the character of auditory experiences as such, and not to the presence or absence amongst the objects of experience of something other than the sounds. Given this, how things appear to us in auditory experience is determined by how sounds appear to us in auditory experience. How sounds appear is a matter of what acoustic properties they instantiate – properties such as pitch, timbre, and loudness – and the way those properties change over time. Sounds appear the same or different to one another in virtue of their instantiation of acoustic properties.

We sometimes talk of the auditory appearance of sound-producing events. We might describe the uncorking of a bottle or the striking of a match as *sounding* a certain way, analogously to the way we might describe the bottle or the match as looking a certain way. When we say that the bottle looks a certain way – that it looks green, say – we are characterising the bottle, and the truth of what we say is determined by how things are with the bottle. It would be a mistake to conclude that when we describe the striking of a match as sounding some way we are directly characterising

the sound-producing event – the striking – rather than characterizing the event in terms of something distinct from it, viz., the sound it produces. We can explain what we mean when we say that the uncorking sounds some way in terms of the sound it produces: in many cases, to say that the uncorking sounded F is just to say that it produced an F sound (a sound with an F appearance). In saying how the event sounds we are characterising it indirectly on the basis of the sound it produces. It does no harm to talk about the auditory appearance of sound-producing events so long as we remember that what we say is made true by the appearance of the sound produced by that event.

Recognising events of the kind I began by describing depends on our having a capacity to group certain sounds together as saliently similar. The sounds made by different kinds of events have a distinctive appearance in common, and in acquiring the capacity to recognise a particular kind of event we learn that the distinctive appearance is that of a sound produced by that kind of event. We might gloss this by saying that we acquire the capacity to recognise the auditory appearance of that kind of sound-producing event.

The possibility of acquiring such a capacity depends on the fact only events of that kind have that auditory appearance. In the right circumstances we can tell, by hearing the sound it makes, that a Zippo cigarette lighter has been opened and struck. Zippo lighters are designed in such a way that they produce a distinctive and characteristic sound, a sound that can easily be distinguished from the sound made by other kinds of event. It is possible to learn, as many of us doubtless have learned, to recognise that sound and so to tell – on the basis of its auditory appearance – that a certain kind of event – a Zippo-lighter event – has occurred.

Suppose that there is another kind of event that produces sounds just like Zippo-lighter events such that we cannot tell them apart. It is not hard to imagine: we might suppose that a competing manufacturer decides to produce cheap off-brand lighters that look and sound like genuine Zippo lighters. They do their job well, and the sounds produced by the opening and striking of these off-brand lighters are just like the sounds made by genuine Zippo lighters: off-brand-lighter events have the same auditory appearance as Zippo-lighter events. If these off-brand events were present in our environment then it would not be possible to tell, on the basis of its auditory appearance, that a Zippo-lighter event had occurred, rather than that an event that was either a Zippo- or

an off-brand-lighter event had occurred. The presence in our environment of off-brand-lighter events would – in the absence of further collateral or contextual information – undermine our capacity to recognise Zippo-lighter events. So our capacity to recognise Zippo-lighter events on the basis of their auditory appearance depends on there not being other kinds of events in our environment that have the same auditory appearance as Zippo-lighter events.

The relation between Zippo-lighter events and their auditory appearance is clearly contingent. The possibility of off-brand lighters events shows that there is no essential connection between the property of being a Zippo-lighter event and the property of having the auditory appearance of a Zippo-lighter event (of sounding like a Zippo-lighter event). But that is hardly surprising. For something to be a Zippo-lighter event it must involve a cigarette lighter manufactured by a particular company (the Zippo Manufacturing Company of Bradford, Pennsylvania), and the relational property of having been manufactured by a particular company can have no direct influence on the sounds that something makes – and so on its auditory appearance. Any lighter that is intrinsically the same as a Zippo lighter – constructed in the same way from the same materials – will produce sounds that are the same as those produced by a Zippo lighter; and clearly lighters that are intrinsically the same as Zippo lighters, such as the off-brand lighter, may lack the relational property of being manufactured by the Zippo Manufacturing Company.

The argument does not undermine the idea that in certain circumstances we can recognise Zippo-lighter events on the basis of their auditory appearance, so it leaves intact the idea that we can hear things on the basis of hearing the sounds they make. But it shows that doing so requires that we be suitably sensitive to the holding or otherwise, on any particular occasion we exercise our recognitional capacity, of various background conditions; in particular, it requires that we be sensitive to the likely occurrence of an off-brand-lighter event. We cannot know that those background conditions hold on the basis of auditory experience, so our knowledge that some event is a Zippo-lighter event, even when acquired on the basis of a capacity to recognise the sounds Zippo lighters make, is not acquired solely on the basis of audition – it is not purely auditory knowledge.

If the argument generalises, then – because all such knowledge would depend on the holding of background conditions whose

obtaining could not be known on the basis of auditory experience – it would undermine the idea that we have any purely auditory knowledge of sound producing events. To show that there can be purely auditory knowledge of sound producing events we need to show that there are some kinds of event which meet the condition that there are no events of a different kind with the same auditory appearance.

There is an obvious reason for doubting that the argument generalises. Being a Zippo-lighter event is not an intrinsic property of an event and just as we would not expect non-intrinsic properties to determine the visual appearance of an object, so we would not expect non-intrinsic properties to determine the auditory appearance of an event. But that gives us no reason to doubt that there are intrinsic properties of events that do determine their auditory appearance.

Whether there are such properties might seem to turn on our view of the nature of sounds and their acoustic properties. I suggested that how things appear to us in auditory experience is determined by how sounds appear to us, and that the way sounds appear is determined by the acoustic properties they instantiate. It is sometimes supposed that acoustic properties are merely subjective sensory qualities. Hume, for example, thought that ‘Sounds, colours, heat and cold, according to modern philosophy are not qualities in objects, but perceptions in the mind’.² According to this line of thought, acoustic properties are sensory qualities that are not to be identified with any properties of material objects or events. Our experiences of sounds having such sensory qualities might be caused by physical or material events of certain kinds, and the causal connection might be sufficiently reliable that we could come to recognise (given knowledge of the background conditions) those kinds of events on the basis of the experiences, but there is no essential connection between the sensory qualities of the sounds we experience and the material causes of our experiences of them. The very same qualities could have been instantiated by sounds with a different material cause. Given that the very same qualities could have been instantiated by sounds with a different material cause, there are no properties of sound-producing events that escape the Zippo argument. So if acoustic properties are subjective sensory qualities, our capacities to

² David Hume, *Treatise of Human Nature*. Selby-Bigge, ed. (Oxford: Clarendon Press, 1911), Bk III, part I, Sect. 1, p. 177; and Bk I, IV, IV.

recognise sound producing events will always depend on the holding of background conditions that connect sounds with certain kinds of sensory qualities with material events of certain kinds and we can have no purely auditory knowledge of sound-producing events.

Subjectivism about acoustic properties is implausible, however, and the arguments in favour of subjectivism are not widely accepted. It is more plausible to think that acoustic properties are identical to physical properties of material objects,³ in particular to the vibrations of objects. According to this view, certain physical properties have a distinctive auditory appearance and acoustic properties just are physical properties picked out in terms of their auditory appearance. If that is right then it is not, as the subjectivist would claim, that vibratory events cause experiences of sounds with certain sensory qualities; those sensory qualities are the appearance in auditory experience of certain kinds of physical vibratory events. It follows that if two events have the same auditory appearance then they must have physical properties in common too – namely, the physical properties that determine the acoustic properties of sounds.

If physicalism about acoustic properties is true then there are properties of events that are not subject to the Zippo argument. A sound with a particular appearance, that is a sound that instantiates particular acoustic properties, could only be the appearance of a vibratory event with certain physical properties, and two vibratory events of the same physical kind would have the same auditory appearance. Our capacity to recognise these kinds of event on the basis of their auditory appearance does not depend on the holding of background conditions, so we can have purely auditory knowledge of them.

If this line of reasoning is correct then auditory perception enables a kind of cognitive contact with the world. But it falls short of what we might have hoped for. If our purely auditory capacities for recognising kinds of event are limited to vibratory events then our purely auditory knowledge is correspondingly limited. What we wanted was an account of our capacities to recognise the kinds of ordinary sound-producing events that I began by describing. Those events – striking a match, winding a clock, and so on – *cause*

³ If acoustic properties supervene on physical properties rather than being identical to them, then the argument that follows would need to be amended. Such an amendment would make no difference to the conclusion: the kind of cognitive contact enabled by supervenience would be no different to that enabled by identity.

vibratory events (or perhaps have vibratory events as parts), but are not themselves vibratory events.⁴ So physicalism about acoustic properties is not itself sufficient to show that our purely auditory capacities for recognising events extend to the ordinary kinds of sound-producing events that I began by describing.

Is it the case that our purely auditory recognition capacities for kinds of event are limited to vibratory events? Suppose there is no essential connection between properties of vibratory events and other intrinsic properties of objects and events. Then even if auditory appearances are the appearances of vibratory events, the connection between the appearances of those events and any other – non-acoustic, non-vibratory – properties of a material objects and events is contingent in the way required for the Zippo argument. Therefore, we can have no purely auditory knowledge of any non-acoustic, non-vibratory feature of a material object or event.

According to the subjectivist, acoustic properties are subjective sensory qualities and therefore our capacities to recognise ordinary sound-producing events will always depend on the holding of background conditions. If we reject subjectivism and hold instead that acoustic properties are identical to physical properties of events, then we can have purely auditory knowledge of physical events. But if our purely auditory knowledge of physical events is restricted to vibratory events, then our capacities to recognise ordinary sound-producing events will also always depend on the holding of background conditions. In moving from subjectivism to physicalism we have simply shifted the problem. The problem for the subjectivist is to explain how hearing sounds – conceived as subjective – can put us in a position to hear ordinary sound-producing events; the problem for the physicalist is to explain how hearing sounds – conceived as certain kinds of vibratory event – can put us in a position to hear ordinary sound-producing events.

This argument depends on the supposition that there is no essential connection between properties of vibratory events and other intrinsic properties of objects and events. There are reasons for rejecting that supposition. The way an object vibrates is determined by its material constitution together with the nature of the event that caused it to vibrate. Given that, a certain kind of

⁴ For more on the relation between sound-producing events, vibratory events, and sounds, see M. Nudds, 'Auditory Perception', in Matthen, ed., *Oxford Handbook of the Philosophy of Perception* (Oxford, Oxford University Press, 2015).

vibratory event could only be produced when an object with a certain shape, size, and material composition is struck in a certain way – that is, by a certain kind of sound-producing event. Therefore that auditory appearance – that vibratory event – could not be the appearance of a different kind of sound-producing event. The same kind of vibratory event could not be produced by an object of a different size, shape or material composition, or by an object struck in a different way. If that is right, then there will be a range of non-acoustic properties of ordinary sound-producing events that escape the Zippo argument. It would follow that we can have purely auditory knowledge of this kind of event, namely an event involving an object with a certain shape, size, and material composition, and struck in a certain way.

Therefore, if we both accept that sounds can be identified with vibratory events and that the character of these vibratory events is determined by the material constitution of the vibrating object together with the nature of the event that causes it to vibrate, then it is possible for us to acquire purely auditory knowledge of at least some ordinary sound-producing events.

There are at least two reasons for doubting that conclusion. The first is that we might doubt whether the properties of material objects and events that determine vibratory events, and so which we could come to know on a purely auditory basis, are properties that are constitutive of ordinary sound-producing events. If they are not, our purely auditory knowledge would still fall short of what we were trying to explain. The second is that it is possible to produce a vibratory event using a loudspeaker that is of the same kind – with the same auditory appearance – as any vibratory event produced by an ordinary sound-producing event. Therefore, there is reason to doubt that there is any essential connection between properties of vibratory events and other intrinsic properties of objects and events, and so to doubt that there can be any purely auditory knowledge of ordinary sound-producing events. I think there are ways to address both these doubts, but rather than do that here, I am simply going to assume that they can be addressed and to turn instead to a different problem: even if we can have purely auditory knowledge of sound-producing events, auditory appearances fail to enable the kind of cognitive contact with the world enabled by vision and touch. The problem turns on the nature of auditory appearances.

Our ordinary conception of the world is a conception of it as containing material objects of various kinds (books, tables, chairs,

cutlery, cats, and cars). To think of these objects as material is to think of them as having those properties we take to be constitutive of material objects. Such properties include position, shape, size, motion, and properties definable when these properties are combined with the idea of force – mass, weight, hardness, etc. Our understanding of these properties involves a theory: ‘[t]o grasp these properties one must master a set of interconnected principles that make up an elementary theory – of primitive mechanics – into which these properties fit’.⁵ In virtue of our grasp of such a theory we understand how an object’s properties determine its causal powers, its behaviour, how it interacts with other objects, and the implications of these interactions for how it changes over time. So to think of an object as an element of the material world is to think of it as having the properties described by the primitive theory of mechanics, and so as falling under the interconnected principles that make up that theory.

Visual perception (and touch)⁶ gives us access to the material world conceived in this way. It does so because the visual appearances of objects are sufficient to fix them as elements of the material world: coming to know the visual appearance of something is coming to know how it fits into the material world as ordinarily conceived. There are two components to this idea. The first is that there is a connection between an object’s appearing a certain way and being that way. There is a range of properties which are such that (in normal circumstances) if an object appears to have one of those properties then it does have that property. For example, if something has the appearance of a cube then it has the property of being cubic.⁷ These properties include properties that we take to be constitutive of the idea of a material object. That means that visual appearances can ground purely visual knowledge of a range of properties of objects that we take to be constitutive of material objects.

The second is that (some of) the properties that constitute an object’s appearance are properties in virtue of which it falls under the interconnected principles that make up the elementary theory. Having that appearance is sufficient for the object to be an

⁵ Gareth Evans, ‘Things Without the Mind’. In Evans, *Collected Papers*. (Oxford: Clarendon Press, 1985: 249–290) p. 269.

⁶ In what follows I only discuss vision, but what I say applies to touch too.

⁷ For a discussion and defense of the existence of such properties see M.G. F. Martin, ‘What’s in a Look’. In B. Nanay, ed., *Perceiving the World*. (Oxford: Oxford University Press, 2010: 160–225); for a different approach see C.A.B. Peacocke, *Sense and Content*. (Oxford: Clarendon Press, 1983), ch. 3.

element of the material world *because* the properties that constitute its appearance are those in virtue of which it is an element of the material world. When an object appears cubic, the property that it appears to have – being cubic – is a property in virtue of which it is an element of the material world. This connection between the properties objects appear to have in visual experience and the properties that we take to be constitutive of material objects is, I suggest, central to our conception of visual perception as enabling cognitive contact with the material world. We do not take the objects of visual awareness to indicate how the world is, or as grounds from which we can infer how the world is: as a consequence of how they appear, we take the objects of visual awareness themselves to be elements of the world. It is in virtue of that fact that we take our visual experience to constitute knowledge that the objects of experience are elements of the material world.

Prima facie, auditory experience is not like this. There is a connection between things appearing a certain way in auditory experience and the occurrence of events of certain kinds – events involving ordinary material objects – in virtue of which we can recognise events on the basis of the way they appear in auditory experience. But the properties that constitute an event's auditory appearance – the acoustic properties of sounds – are not properties in virtue of which it falls under the interconnected principles that make up our elementary theory of the material world. Having that appearance is not sufficient for the object to be an element of the material world *because* the properties that constitute its appearance are those in virtue of which it is an element of the material world. That marks a significant contrast with the visual case.

Instead, the connection between the properties that constitute an event's appearance and other properties of the event is sufficient for us to come to know – in virtue of the exercise of a recognitional capacity – that it has those properties. The properties that we come to know include those in virtue of which it falls under the interconnected principles that make up our elementary theory. So, we might say, auditory experience is sufficient for us to know that something is an element of the material world, but auditory experience does not itself constitute that knowledge. We do not take the objects of auditory experience, in virtue of how they appear, themselves to be elements of the material world.

It makes no difference to this line of argument to think that acoustic properties are physical properties, and hence that auditory appearances are the appearances of certain kinds of vibratory

events. Vibratory events are not events that consist in the interactions of (or changes to) objects as ordinarily conceived, they are the causal consequences of those interactions and changes. When two objects collide, for example, the collision causes a vibratory event; it is that event and not the collision which, according to this view, appears to us in auditory experience.

Vibratory events and their properties do not figure in our ordinary understanding of the material world. It is not part of our understanding of shape, mass, and force that objects with these properties will vibrate in a certain way as a consequence of their interactions, and our grasp of the elementary theory does not relate the properties that we take to be constitutive of material objects to the kind of vibratory events that appear in auditory experience.⁸ So the appearance of a vibratory event in auditory experience does not constitute knowledge of that event as part of the material world, and our understanding of the relation between the vibratory events that appear in auditory experience and material objects and events as we ordinarily conceive them is left open by how they appear in our auditory experience.

Even if we accept that auditory appearances are the appearances of certain kinds of vibratory events, the connection between those vibratory events and objects, events, and their features as we ordinarily understand them is not apparent in experience. It seems, then, that there is a significant contrast between visual and auditory perception. Whereas in the visual case, the objects of visual experience appear as elements of the material world, in the auditory case the objects of auditory experience do not appear as elements of the material world. The connection between the objects of auditory experience and material objects and events is not itself apparent in auditory experience.

I began with a list of different kinds of event that we can recognise on the basis of the sounds they make. When we recognise an event, we categorise it as an event of a certain kind. How do we do this?

One plausible answer views our capacity to recognise ordinary sound-producing events as having a kind of compositional

⁸ I believe it is possible to defend this claim on a priori grounds (see Evans, 'Things Without the Mind'). Our ordinary understanding of objects and their interactions has also been studied empirically. For a survey of some of this work, see E. Spelke and G. Van de Walle, 'Perceiving and reasoning about objects: Insights from infants'. In N. Eilan, R. McCarthy, & W. Brewer, eds., *Spatial representation*. (Oxford: Basil Blackwell 1993: 132–162).

structure: we are able to recognise a number of different basic events; ordinary sound-producing events are structured sequences of these basic events; so we are able to recognise ordinary sound-producing events on the basis of recognising the pattern of basic events that makes them up.

In support of this answer is the thought that it is possible to categorise sounds according to the kinds of basic event that produce them. Gaver suggests that an initial categorisation might begin by distinguishing sounds produced by solid objects, liquids, and gasses.⁹ We can further distinguish the different ways a solid object can produce a sound: by impact (discrete, relatively short inputs of energy), by scraping (continuous inputs of energy), by rolling movements, and by deformation (crushing or crumpling); and we can go on to make further distinctions amongst each of these different kinds of event. For example, the texture, material, speed, acceleration or force of a scraping may affect the sound produced, so we might distinguish correspondingly different kinds of scraping event. Differences in physical or material properties may affect the sounds produced by the other kinds of event, and so we might distinguish them accordingly. In this way we end up with categories that correspond to a range of different kinds of basic event that produce sounds. Since this process of categorisation distinguishes basic events on the basis of differences between the sounds they make, it is plausible to suppose that we could come to recognise kinds of basic event on the basis of the sounds that they produce.

Many of the ordinary events that we recognise are complex, made up of sequences of basic events. We can recognise these complex events on the basis of the pattern of simple basic events that make them up. For example, a match being struck involves the striking sound of the match and then the flaring sound of its lighting; a door being shut makes a scraping sound followed by the sound of an impact.¹⁰ If we are able to recognise the basic events that make up complex events, then we can recognise complex events by drawing on our knowledge of how they are structured out of basic events. If our capacity to recognise ordinary events is compositional in this way, then it can be explained

⁹ See W. Gaver, 'How do we hear in the world? Explorations in ecological acoustics.' *Ecological Psychology* 1993, 5: 285–313.

¹⁰ See W. Gaver, 'What in the world do we hear? An ecological approach to auditory source perception'. *Ecological Psychology* 1993, 5: 1–29.

in terms of capacities to recognise (perhaps a limited number of) basic events.

How do we come to recognise basic events? One way to think of basic event recognition is by analogy with object recognition. We recognise an object as an object of a certain kind by perceiving it to have the features characteristic of that kind of object. So, by analogy, we recognise a basic event as an event of a certain kind by perceiving it to have the features characteristic of that kind of event. These features might be the features that determine it as an event of that kind. For example, we might perceive an object and perceive the way that the object is changing and, in virtue of that, recognise that an event of a certain kind is occurring: we recognise a person's walking because we perceive the person and the way they move. Walking is an event that involves a person moving in just that way, so we are able to recognise that the person is walking on the basis of seeing them moving that way.

An alternative way to think of basic event recognition rejects the idea that we do so by perceiving the features characteristic of the event, and appeals instead to the idea that can we recognise an event by perceiving some distinctive cue or cues to its occurrence. Sounds produced by different basic events have distinctively different acoustic properties. Given this, it is plausible that we could recognise a basic event on the basis of hearing the sound that it makes without perceiving features of the event: the distinctive acoustic properties of the sound can instead function as a cue to the kind of basic event that produced it. The cue may be simple – it may amount to a single property that in the context reliably indicates the kind of event in question. Having the property that constitutes the cue need not be characteristic of the kind of event in question and in the auditory case, perceiving the cue does not constitute perceiving some feature of the basic event.

The compositional account of auditory event recognition and categorisation sketched above is consistent with the idea that we recognise basic events by perceiving an auditory cue to their occurrence. Whilst it is true that we perceive complex events by perceiving their characteristic structure – the way in which they are made up of simpler events – the account does not require that we perceive the characteristic properties of the basic sound producing events that determine them as the kind of events that they are. It merely requires that we are able to recognise and categorise these basic events. We could do that on the basis of perceiving

some relatively simple auditory cue to their occurrence. So the compositional account together with a cue-based account of our capacities to recognise basic events might seem to offer the best explanation of our abilities to recognise ordinary sound-producing events.

According to this picture, we recognise sound-producing events on the basis of perceiving the sounds that they make, but properties of those sound producing events do not appear to us in auditory experience. We perceive sounds and their acoustic features, and on that basis are in a position to know that certain basic events are occurring, but we do not perceive the properties of the basic events themselves. If this account is the whole story, then auditory perception contrasts with visual perception and touch in the way I described above: auditory appearances are not the appearances of elements of the material world.

The compositional and cue-based account offers a plausible account of at least some instances of our capacity to recognise sound-producing events. Is it true of all cases? In what follows, I draw a comparison between the auditory and visual perception of movements in an attempt to show that it is not.

In vision we can discriminate movements that differ in their dynamic properties. When someone picks up an object we can see from the way they move how heavy it is. Their movement when they pick up a heavy object is different to their movement when they pick up a light object. This is often jarringly apparent in films when the protagonist's supposedly heavy suitcase is lifted and is quite obviously empty; or when a 'heavy' rock is lifted off the ground and it is immediately apparent that the rock is a painted block of polystyrene. The difference in the movements is due to a difference in the forces acting on the body of the person lifting the weight resulting in visible differences in the dynamic properties of their movement – in particular the acceleration of the movement. These dynamic properties are visible in the case of non-biological movements too. When one rolling ball strikes another and causes it to move, it is possible to perceive the relative masses of the two balls. Their masses determine the acceleration of their subsequent movements and differences are visible.

Our ability to discriminate the dynamics of movements has been investigated experimentally. In one experiment, observers were able to 'distinguish the inanimate motion of a falling and bouncing object from the animate motions produced when the same object is moved by hand along the same path, to the same

endpoints, and at the same frequency' or velocity.¹¹ Again, the difference between the movements of the two objects is a difference in their dynamic properties, in particular in the way their velocity changes. The dynamic properties of the animate motion reflect an input of energy, whereas those of the inanimate movement reflect dissipation of energy. These differences in the dynamics of the movements are visible to the observer and the differences in the forces acting on the objects are visible in the way they move.

We can conceive of the motion of an object as consisting in its occupying a series of different locations at different times (i.e. in the succession, over an ordered series of times and locations, of the instantaneous states of an object at each location and time). Given this conception of motion, we might suppose that the capacity to see an object move consists in the capacity to see a sequence of states of an object. We can think of this as a reductive account. The perception of movement is explained simply in terms of the perception of an object over time, and does not involve anything over and above the capacity to see, from one moment to the next, where an object is. On this account, to discriminate between the different movements of an object would require us to judge differences in the time taken by an object to occupy a series of locations and on that basis to judge differences in the dynamic properties of the object's movement.

This reductive explanation is implausible. To tell which of two objects has the greater mass on the basis of the timing of their occupation of a series of locations would require the application of quantitative physical principles. It is implausible to think that we apply such principles in discriminating movements: both because it is doubtful that we can perceive the timing of the series in the precise way required to apply the principles, and because we lack the capacity to perform the computations required by them.

A better explanation of our capacity to discriminate these different movements is that we have a dedicated visual capacity for the perception of movements (and perhaps other kinds of events). That is, our visual system is able to recover information sufficient to work out – via the operation of a computational process – the dynamics of an object's movement from visually detected motion, and so produce a representation of the movement and its dynamic

¹¹ G. Bingham, 'Dynamics and the Problem of Visual Event Recognition.' In T.R. Port and T. van Gelder, eds., *Mind as Motion: Dynamics, behaviour, and cognition*. (Cambridge, MA.: MIT Press 1995. 403–448), p. 409.

properties. To suppose this is to suppose that movement events are represented as such by the visual system in much the same way that objects are represented as such, and hence that movement events are among the 'objects' of visual experience.

Further support for this suggestion comes from the fact that in some cases we see an object as a consequence of seeing movement, not the other way around. This is clearly demonstrated in 'patch light' displays. In these displays, lights are attached to points on the surface of an object, and the object is viewed in such a way that only the patches of light are visible. When stationary, the pattern of light is unrecognisable – a meaningless pattern of spots – but when the lights move, the object is immediately apparent. Perhaps the best known example of this kind of display is Gunnar Johansson's films of a person walking.¹² Johansson filmed people in such a way that only the lights attached to their joints were visible. When static, the lights have no apparent connection to one another, but once the lights begin to move, we immediately see a walking person. The effect is striking and involuntary – the structure revealed by the moving lights pops out as a kind of moving gestalt. This phenomenon occurs in patch light displays of many kinds of event including rolling balls, ripples on water, and swinging pendulums¹³. These examples illustrate the perception of structure from motion. They show that the visual system is able to extract information about the structure of an object by interpreting local patterns of motion on the retina as the movement of that object. In these cases, the representation of the object is not independent of the representation of the movement of the object, and that undermines the idea that the capacity to see an object move consists in the capacity to see a sequence of states of an object.¹⁴

We experience movements as having a distinctive visual appearance. When we see someone lifting a supposedly heavy weight too easily the movement literally *looks* wrong – it has a visual

¹² See G. Johansson, 'Visual perception of biological motion and a model for its analysis,' *Perception and Psychophysics*. 14, 1973: 201–211.

¹³ See G. Bingham, R. Schmidt, and L. Rosenblum, 'Dynamics and the Orientation of Kinematic Forms in Visual Event Recognition'. *Journal of Experimental Psychology: Human Perception and Performance*. 1995, 21, 6: 1473–1493.

¹⁴ For a recent discussion that presents evidence in favour of the same conclusion about the perception of intentional movement see B. Scholl and T. Gao, 'Perceiving Animacy and Intentionality: Visual Processing or Higher-Level Judgement?' In M. Rutherford and A. Kuhlmeier, eds., *Social Perception: Detection and Interpretation of Animacy, Agency, and Intention*. (Cambridge, MA. MIT Press, 2013: 197–230).

appearance that is inconsistent with the movement of a heavy object. When we see the movement of an object falling under gravity the movement has a distinctive appearance, and it looks different to that of an object moved by hand. This lends support to the suggestion that the visual system represents movements and their properties: the computational process that produces such representations results in, and explains, a visual experience of movements that have a distinctive appearance (in much the same way that the visual system performs complex calculations to determine the reflectance of an illuminated surface, which results in an experience of a surface that has a distinctive appearance).

It is the distinctive visual appearance of different movements that enables us to discriminate between movements that differ in their dynamic properties, and on the basis of which we can perceive properties of the things that move and the different forces that resulted in the movement. In discriminating between different movements we are discriminating between events that have distinctive visual appearances.¹⁵

So we can perceive movements and their properties, and movements have a distinctive visual appearance that cannot be reduced to the static appearance of objects and their locations over time. Suppose that something similar is true of auditory perception: that there is a perceptual process, analogous to that in vision, which functions to represent certain kinds of events that produce sounds we hear.

In this final section of the paper, I will suggest that two claims are plausible. First, that there is information about movement in the structure of the sounds produced by (some) movements that the auditory system can and does extract as part of a process that functions to produce representations of the movements that produced the sounds. Second, that movements have a distinctive auditory appearance, grounded in the temporal structure of sounds, in such a way that we can think of the appearance of a movement event in auditory experience as the appearance of an element of the material world as ordinarily conceived.

The sound made by a rolling ball – for example, a marble rolling across the desk – is distinctive and is easily recognisable; the rolling of a ball is a good candidate for being a basic event. There is empirical evidence that, in addition to being able to

¹⁵ For a survey see G. Bingham, R. Schmidt, and L. Rosenblum, 'Dynamics and the Orientation of Kinematic Forms in Visual Event Recognition'.

recognise the rolling of a ball, we can tell the speed at which it is rolling, and the relative size of the ball.¹⁶ It is also possible to tell when the ball changes speed: whether it is speeding up or slowing down, for example. This experimental evidence confirms something that I think is fairly familiar. It is easy to imagine the sound made by a marble dropped into a large metal dish and allowed to roll back and forth until it settles, and to imagine how you could tell what was happening to the ball: to tell when the ball was rolling up the side of the dish and when down, to tell when it had reached the apex of its movement, and to tell when it was at the lowest point of its movement. As far as I know the question of whether it is possible to perceive the differences in the way a ball is caused to move (for example, to tell the difference between a ball that rolls under the influence of gravity and one that is caused to move by being struck) has not been tested, but I think it is possible that this difference is also perceivable.

How should we explain our capacity to recognise these features of a rolling event? We might do so by appeal to the kind of cue-based account I described above. The rolling of a ball produces sounds with a distinctive appearance on the basis of which we could recognise the kind of movement that produced the sound. Furthermore, the sound produced by a rolling ball that speeds up has a different appearance to that produced by a rolling ball that slows down; the sound produced by a ball that is rolling fast has a different appearance to that produced by a ball that is rolling slowly; and so on. So it is reasonable to think that we could come to recognise these different events by learning to discriminate between the different sounds.

But I think that there is an alternative: that what is true of visual perception is true of auditory perception. Just as we have a visual capacity for movement perception, so we have an auditory capacity for the perception of certain kinds of events.

To defend this alternative we need to show that the auditory system could function in such a way as to produce representations of the rolling of a ball. In favour of this possibility is the fact that there is information available in the pattern of frequency components of the sound produced by the rolling that would be sufficient for the auditory system to work out that a rolling event is

¹⁶ See M. Houben, A. Kohlrausch, and D. Hermes, 'Auditory cues determining the perception of the size and speed of rolling balls'. *Proceedings of the 2001 international conference on auditory displays, Espoo, Finland*. Espoo, Finland: Conference organization, 2001: 105–110.

occurring. This information is embodied in the temporal structure of the sound, in particular in the sound's periodic properties. The sound of rolling is periodic because the rotation of the ball is periodic, and any small perturbation in the sphericity of the ball will modulate the sound it produces in a periodic way. This periodicity, and changes to it, carries information that specifies the occurrence of a rolling event. On a much smaller scale, the surface of the ball and that of the surface on which it rolls are not perfectly smooth. We can picture both at a microscopic level as being sawtoothed. As the ball rolls over the surface, these teeth strike together in a sequence of tiny impacts. The pattern of impacts is characteristic of a rolling object, and carries information about the speed of the rotation, as well as other properties of the ball including its material composition and its mass. They produce a vibration that is detected by the auditory system. Given this, I think it is not implausible that the auditory system could extract information from the pattern of frequency components produced by the rolling ball sufficient to produce a representation of a rolling event, and to represent that rolling event as having a range of properties.

Such an auditory capacity for perception of the movement would not depend on the perception of change in the spatial location of the moving object. It may be that we hear a rolling ball move from left to right in front of us, and so perceive the change in spatial location of the ball as it rolls. But perceiving the change in location is not perceiving the rolling. A rolling movement often involves a change in location, but need not do so (I have in mind, for example, the kind of ball bearing that rolls but is held fixed in position): they are distinct kinds of event.

Just as in the visual case there is a distinctive way movements appear, so I think we can make sense of the idea that in the auditory case there is a distinctive way rolling movements appear: that in hearing the rolling sound, the event – the rolling – is apparent to us. In the visual case, movements have an appearance that cannot be reduced to something more basic. When we see movements, there are high-level properties of the movements, represented as a result of a visual capacity for the perception of such properties, that are visually apparent to us. In the auditory case, movements – in particular rolling movements – have an appearance that cannot be reduced to something more basic. When we hear rolling movements, there are high-level properties of the movements that are apparent to us in auditory experience.

These properties are represented as a result of an auditory capacity for the perception of such properties on the basis of information extracted from the temporal properties of sounds.

If two different rolling movements appear differently in auditory experience, what does this difference consist in? There are high-level properties of the movements that are apparent to us and in virtue of which the movements appear different. These differences in high-level properties are grounded in differences in the temporal properties of the rolling movements. The temporal properties of the rolling movements are the same as the temporal properties of the sounds produced by the rolling movements. Both the event and the sound have the same temporal properties across a range of scales, from properties determined by the interaction of the surface of the ball and the surface on which it rolls, and the periodic properties that are consequences of rotation, to the time taken for the rolling movement to be completed. That means that the appearance of the temporal properties of the sound is itself the appearance of the temporal properties of the rolling movement. Rolling movements are apparent in auditory experience because the temporal properties of the sounds they produce are apparent in auditory experience, and the appearance of those properties is the appearance of temporal properties of the movement. Different high-level properties of the movements are grounded in these different temporal properties. In an analogous way, two faces can appear visually different, and the difference between them consists in differences in the spatial arrangement of their parts. But they do not appear different simply in that they appear different in their spatial properties; they appear different in some higher-level properties that are grounded in their spatial properties.

The properties of rolling movements can be apparent in auditory experience because they are higher-level properties of movements grounded in temporal properties that are apparent in auditory experience.

If what I am suggesting is right, we do not simply perceive a cue to the kind of event that produces the sound; in the case of rolling movements at least, we are able to perceive properties of the events themselves, and we are able to recognise what kinds of events they are on the basis of how those events appear in auditory experience.

My aim has not been to offer a demonstrative account in favour of this suggestion, but to provide an alternative to the cue-based

account. I have only offered the barest sketch of what this alternative might look like, and much more needs to be done to show that it provides a better explanation than the cue-based account. However, if that can be done, the account provides a way to respond to the second problem that I outlined above – that the apparent properties of the objects of auditory experience are not those in virtue of which they are elements of the material world. It does so because the temporal features and the high-level properties that constitute the auditory appearance of movement are plausibly features that figure in our ordinary conception of the material world.

The elementary theory that grounds our understanding of the properties constitutive of material objects includes principles that relate the material properties of objects to the ways objects interact. Principles that describe, for example, how an object's shape determines how the object will affect and be affected by other objects, and principles that describe the consequences of mass for the way an object moves and interacts with other objects. The elementary theory includes principles governing the dynamic behaviour of objects and underpins our understanding, for example, of what it is for a ball to roll, and of what the consequences are of one ball striking another. The appearance of a rolling movement is the appearance of an event that, in virtue of being the way it appears, is governed by the principles of the elementary theory. So in having that appearance it appears as an element of the material world.

My focus has been on rolling movements. If the general approach that I have sketched is along the right lines, then it ought to be possible to extend the approach to show that properties of a range of different kinds of sound-producing events are apparent in experience. That would show that, although not all sounds present the appearance of sound-producing events, those that do ground the same kind of cognitive contact with elements of the material world as vision (and touch) do, and therefore that our auditory access to the world goes beyond cue based recognition of material events: the events themselves are apparent to us in auditory experience.

University of Warwick
Coventry CV4 7AL
matthew.nudds@warwick.ac.uk