Physicalist vs. Ecological Accounts of Perceptual Content: Lessons from Timbre

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1. Introduction

We tend to talk about our perceptual experiences in two ways. Sometimes we characterize the quality of our experience directly: the apple "looks red"; the wine "tastes bitter." Frequently, however, we describe an appearance by referring to its (presumed) external cause: the apple "looks ripe"; the wine "tastes high in tannins." These two intuitive ways of talking about experience illustrate a fundamental assumption behind perceptual science: the qualities of experience correlate with properties in the world. Historically, our intuitive theories about these external correlates served as a starting point for the psychophysical investigation of experience. But what happens when we have no intuitive theory at all—neither a specialized term for the quality of an experience, nor a sense of its external cause? Arguably, this is the case for *timbre*, a characteristic of sound for which there is neither a standard terminology, nor a consensus causal theory.

Timbre is typically defined as that feature of a sound which distinguishes it independent of its pitch, volume, duration, or attributed spatial location. As such, the concept of timbre is a kind of "dustbin" for auditory qualities, encompassing anything about sound we don't really understand. As a feature of sounds, timbre is strikingly similar to color as a feature of surfaces (*n.b.* the German word for timbre, *Klangfarbe*, literally "sound color"). Both appear to be mysterious "extra" qualities which contrast with more transparent ones—spatial location (surfaces and sounds), extension and orientation (surfaces), and pitch and volume (sounds)—for which the external correlates are rather straightforward. Consequently, it is perhaps no surprise that the two most popular approaches to understanding the correlates of timbre mirror the two most popular accounts of the external correlates of color, the physicalist and ecological theories. As a general principle, one might hope to gain insight into how perceptual content works by comparing and contrasting different sensory modalities. What can we learn about color—and secondary qualities in general—from the debate over the correlates of timbre?

In the remainder of the paper, I examine a typically unrecognized source of evidence for the external correlates to a perceptual experience: practice in the arts. After arguing that color control through the use of artificial pigments in painting supports physicalist over ecological accounts of color, I summarize the current state of our understanding of timbre perception in a musical context. I argue that the ecological account of timbre stands or falls with the negation of a particular theory about how we experience music, the acousmatic thesis, and I survey the evidence from contemporary musical practice relevant to the physicalist / ecological dispute. This discussion demonstrates the value of works of art as "natural experiments," of interest to both the philosophical and psychological investigations of perceptual experience.

2. Artistic Control as Evidence for Color Physicalism

From the standpoint of physics, light sources emit rays composed of various wavelengths of light (their spectral power distributions), these rays bounce off surfaces, which reflect different wavelengths at different efficiencies (their surface spectral reflectances), and the resulting signal impinges on the retina. Our attribution of colors to surfaces, and the relative invariance of this attribution across different lighting conditions, motivates the *physicalist* analysis of color content, the view that the external correlates of color experience are the spectral reflectance properties of surfaces (Byrne & Hilbert, 2003; Churchland, 2007).

From the ecological standpoint, color vision evolved to help us navigate our environment successfully. For instance, red–green opponency allows us to more easily identify edible fruits and vegetables against a leafy background. One might think that the external correlates of color should then be identified with biological properties of interest to evolving humans (e.g. green with the presence of chlorophyll), but this view appears to be defeated by the statistical predominance of artificially colored surfaces in our current environment (green paint is not typically made from chlorophyll). This consideration forces the *ecological* analysis of color content to make the relatively weak claim that color experience serves the function of simply differentiating surfaces. Philosophers who endorse the ecological view differ on whether the properties which serve this function should be interpreted as primitive (Noë, 2004) or relational (Hatfield, 2003).

One mark of the correct identification of the external correlates to an experience is the ability to systematically control that experience through manipulation of external properties. By this standard, the practice of painting appears to support physicalism. For when we manipulate color experience through the use of artificial pigments, it does not matter what these pigments are made from (and in particular they need not be fashioned from substances of biological interest on an evolutionary scale), but merely that they effect the spectral reflectance of the surface to which they are applied. Furthermore, far from differentiating surfaces, painters often aim to match surface appearance through judicious pigment mixing, with remarkable success.

3. Ecological and Physicalist Accounts of Timbre: A First Pass

The physicalist account of timbre originates with Helmholtz (1885), who attributed timbral difference to differences in *overtones*. This account depends upon first, identifying a sound with its Fourier transform, i.e. its decomposition into sine waves of various strengths, and second, identifying timbre with the component waves other than the lowest, "fundamental," frequency, i.e. the "overtones." For instance, a violin typically produces vibrations (in decreasing amplitudes) at all "harmonic" overtones, i.e. sine waves with frequencies in whole number ratios with the fundamental frequency, comprising a wave typically described as "sawtooth" in shape. Conversely, a clarinet typically suppresses even numbered harmonics, generating a wave typically described as "square" in shape.

Helmholtz himself, however, recognized that this physicalist analysis was as yet inadequate as a full account of timbre. At the very least, the volume envelope (the rate of volume increase, or "attack," level of "sustain," and rate of volume decrease, or "decay") contributes to our assessments of timbre. If I record a clarinet note, for example, then change its volume envelope by fading its volume up gradually, then fading it gradually back down again, it will sound very like a violin note. This phenomenon does not defeat the possibility of providing a physicalist characterization of timbre, but it demonstrates that a much more sophisticated analysis than Helmholtz's first pass is required, an analysis which has yet to be produced.

Recent philosophical interest in the ontology of sounds has motivated an ecological analysis of timbre. O'Callaghan (2007), for instance, identifies sounds with

events which disturb a medium; he identifies timbre with the *manner* in which the medium is disturbed (88–90). So, for instance, the fact that the sound of wind instruments is produced by blowing across a column of air, while the sound of string instruments is produced by dragging one string across another, explains the family resemblance amongst the sounds produced by these respective groups. This account also explains similarities across non-musical sound sources—all "squeakings" share a timbral similarity because they are all produced by the dragging of a slightly sticky surface across a slick one, likewise sounds produced by "knocking," "scratching," etc. This basic analysis of timbre had already been stated in the music perception literature by Balzano (1986) who characterizes timbre as determined by "dynamical sound-producing processes" (310), a view he explicitly traces to Gibson's (1966) claim that: "The train of waves is specific to the kind of mechanical disturbance at the source" (81).

Despite its intuitive appeal, the ecological view is still not sufficiently developed to allow the systematic manipulation of timbre experiences via the systematic manipulation of external sound-producing mechanisms. A mature ecological theory would provide a complete taxonomy of sound production types, and a precise specification of how they differentially effect timbre experience.

4. The Acousmatic Thesis

The ecological analysis of timbre plays a critical role in the debate over the "acousmatic thesis" in the aesthetics of music. The acousmatic thesis claims that our perception of sounds *as music* is divorced from the (causal, spatially located) processes which produced those sounds. It is important to recognize that the claim is not that one cannot attend to spatial locations and causal sources when listening to music, but rather that when an experience is a musical one, its intentional content does not include those sources.

The acousmatic thesis is usually attributed to the French electronic music pioneer Pierre Schaeffer (originator of *musique concrète*), and has recently been championed by philosopher Roger Scruton (1997; 2009).[1] However, as Hamilton (2009) argues, the phenomenon of timbre is problematic for the acousmatic thesis. Hamilton essentially

[1] Note that Scruton (2009) uses the term "physicalism" in a different sense from the present paper. Both physicalist and ecological accounts of content are "physicalist" in Scruton's sense.

assumes the ecological account of timbre, but argues that timbral manipulation in some musical traditions leaves room for the possibility that it is experienced acousmatically. For him, this turns on whether or not structural features of a musical composition rely on timbre. Although this is not typically the case with "Western classical music," which focuses primarily on the structural organization of pitch, he argues it may be true for various 20th century and non-Western forms of music. The only other option he sees for the acousmatic account is to simply deny that timbre is properly part of musical experience, a move which I find phenomenologically implausible.

From a psychological standpoint, the pertinent question is how to account for invariances in our timbre attributions. We group some sounds together as similar in timbre and distinguish them from others which differ in timbre. Can these judgments be characterized acousmatically, i.e. without reference to sound sources? By this criterion, I think the physicalist account is consistent with the acousmatic thesis, but the ecological account is not.

If the physicalist theory of timbre is correct, then timbre attributions can be viewed as a function of properties of the waveform incident at the ear, in particular, its overtones and volume envelope. Although this account analyzes the content of sound experience in terms of external physical properties, it does not presume that these properties are directly accessible in experience (just as color physicalism does not assume that we can discover surface spectral reflectance through introspection about colors). Nevertheless, sound experience has features which correspond directly to both overtones and volume envelope. In the case of volume, the amplitude of the wave corresponds to its perceived loudness. In the case of overtones, the correspondence is with pitch relationships. On this view, timbre is just a special case of harmony, and the timbre of a tone can then be described acousmatically by treating that tone as itself a chord (i.e. in terms of its harmonic composition) with a particular pattern of increasing and decreasing loudness.

Conversely, the ecological account does not suggest any straightforward recipe for describing timbre without reference to the sound source. If the ecological theory is correct, then, the invariances in our attributions of timbre are best characterized in terms of invariant mechanisms of sound production. Any account in purely perceptual terms would be gerrymandered and opaque. Compare, for instance, the use of causal terms by experts to refer to the taste of wine or the smell of perfume (wine: "young",

"corked"; perfume: "animalic", "floral"). It's more efficient and direct to speak in causal terms because an account in terms of pure experience would be vague and roundabout, would fail to pick out with precision the actual perceptual experience. If this turns out also to be the case with timbre, if sounds which are "like a violin" or "squeaky" or "scratchy" have no transparent description in terms of pure experience, then Scruton's claim that "reference to a source is not essential to the identification of the sound" (2009, 62) will turn out to be incorrect.

The ecological theory and the acousmatic thesis are both claims about the intentional content of sound experience, i.e. claims about what that experience is about, or directed at. The ecological theory is an account of timbre content in all contexts, whereas the acousmatic thesis is an account of sound content in a musical context only. If the analysis above is correct, then the ecological theory stands or falls with the negation of the acousmatic thesis. If the ecological theory is correct, and if timbre is part of musical experience, then musical experience is not divorced from spatiotemporal causes, and the acousmatic thesis is incorrect. Conversely, if the acousmatic thesis is correct, then either timbre is not part of musical experience (a phenomenologically dubious conclusion), or the ecological account of timbre, at least as characterized here, must be incorrect.

Unfortunately, it's difficult to see how one might confirm or disconfirm the acousmatic thesis experimentally. Empirical evidence for the correct analysis of timbre, however, can be found in musical practice.

5. Timbre Control in Music: A Scorecard

In the 20th century, composers strove to use the power of new technology to expand the repertoire of musical expression; their efforts in these directions constitute "natural experiments" on the nature of timbre. Especially important here was the newfound power of electronic synthesis: first analog synthesizers, then digital computers, gave composers complete control over sound. This control offered the promise of a rich new palette of timbres, unfettered by the limitations of traditional instrumentation. Unfortunately, this promise appears not to have been realized; in the words of one of Balzano's colleagues: "in the past 30 years we have come up with one new timbre, 'electronic'" (298).

Balzano considers this anecdotal observation to concisely summarize a broad sentiment across the musical community, one which tolls the death knell for the physicalist account of timbre. The reason is simple: typical synthesizers directly manipulate the overtones and volume envelopes of sounds, i.e. those properties the physicalist claims correlate with timbre. If these manipulations are classified perceptually as a single timbre (an empirical claim), then the physicalist has failed to correctly analyze the features which determine timbre experience. Balzano suggests that any distinctive timbral categories generated via computer will have to rely on models of physical processes (310). This does not imply that it will be *impossible* to generate new timbres electronically, but it does imply that possible timbres will be sharply delineated by possible physical processes and, in particular, the question of whether there are new timbres to be discovered collapses into the question: "are there fundamentally new ways of making sounds in the real world that have not been discovered yet?" (311).

Additional evidence for the ecological thesis might be found in the use of extended techniques. An extended technique makes sound from an instrument in a non-traditional way, for example: John Cage's "prepared piano" has foreign materials (e.g. a fork) inserted between its strings; Karlheinz Stockahusen's *Mikrophonie I* uses brushes and other non-standard implements on the surface of a gong; a host of similar techniques have been pioneered in the "free improvisation" movement, for instance Keith Rowe's use of a prepared electric guitar, played with toothbrushes, rubber bands, an electric fan, etc. The relevant point about extended techniques is that, while the sounds may be novel, they do not necessarily constitute new timbres, and in general are most easily categorized by the type of physical interaction with the instrument. Stockhausen, for example, despairing at the complexity of describing specific actions in the score for *Mikrophonie I*, used instead general terms for the *types* of sound-producing activity, e.g. klappernd ("clapping") or sägend ("sawing") (1989: 82–6).

While the preponderance of the evidence falls on the side of the ecological thesis, there is some evidence for the physicalist account of timbre. Influential 20th century organist and composer Olivier Messiaen, for example, was famous for taking inspiration from bird song in his compositions. He emphasizes that "in order to translate these timbres, harmonic combinations are absolutely necessary . . . each note is provided with a chord, not a traditional chord but a complex of sounds destined to give the timbre of

that note"(1994: 94–5). Likewise, engineer William Sethares (1998) has used a combination of mathematical analysis and cross-cultural studies to argue that there is a close relationship between timbre (as measured in pattern of overtones) and scale (i.e. the pattern of intervals employed in organizing music by pitch). For example, the Javanese gamelan employs a scale which does not repeat at the physical octave, but is nevertheless tuned very precisely across many instruments and ensembles. Sethares explains this fact by demonstrating that the overtones produced by gamelan instruments are consonant with the pitch intervals employed in gamelan scales. Both Messiaen and Sethares demonstrate that the physicalist theory of timbre can explain important aspects of musical practice.

This brief "scorecard" is far from complete. I hope it demonstrates, however, that musical practice provides a rich testing ground for theses about timbre, and that conceptual questions about the ontology of timbre can be translated into empirical questions about our experience of music.

6. Conclusion

We typically conceive of our perceptual experience as correlating with properties in the world. Psychologists study these correlations through psychophysical methods, while philosophers analyze them in terms of intentional content. An often overlooked source of evidence on this issue is practice in the arts. The artistic attempt to manipulate perceptual experience makes assumptions about its external correlates, and the success or failure of an artistic technique provides evidence for or against its assumptions about content. A vivid example is the exploration of timbre in contemporary music, where the general failure of physicalist strategies in the electronic domain appears to support the ecological theory.

If we aspire to a unified account of the intentional contents of perceptual qualities, then the apparent success of the ecological theory of timbre poses a challenge to physicalists about color and other qualities. Even if we are willing to settle for a heterogeneous account of content, the example of timbre demonstrates the rich interaction between perceptual theory and artistic practice.

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