CHAPTER 36

SIMILARITY SPACES

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1 Introduction

No relationship is of greater significance in perceptual processing than that of perceptual similarity. Visual stimuli appear (‘look’) the same or different in hue or shape or size, auditory stimuli appear (‘sound’) the same or different in pitch or loudness or distance away, gustatory stimuli appear (‘taste’) the same or different in sweetness or hotness or richness, and so forth. Virtually all philosophers and scientists studying the mind take perceptual similarity to be, in one way or another, the foundation of the perceptual types—blue, round, loud, loudest, less than ten feet away—into which we classify the stimuli we perceive. To that extent, apprehension of perceptual similarity determines how we experience the stimuli in our environment, how we explain and predict their behaviour, and how we behave toward them. Mobilization of perceptual categories enables us to reason inductively about the world around us and, in general, to learn.1 Hence our perception of similarity must be key to our survival. Mohan Matthen observes:

The senses are essentially classificatory systems. They assign stimuli to classes, order these classes in similarity relations, and provide sensory consciousness with awareness of the results of this activity. Thus, sensory consciousness is articulated in terms of class membership, in the subsumption of individual stimuli under classes, and similarity relations. (2005: 150)

Central to perceptual similarity are a variety of ordering relations: one object will look bluer or larger, or darker or brighter, than another, and one tone will be louder than another, or sound more stable or more tonally centred in a given musical key. Often these orderings are conceived as delineating an abstract geometrical space in which distance represents degree of similarity on a given dimension (hue, stability, relative importance, etc.). In other words, a perceptual space is an abstract space in which relative similarity

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1 Indeed, some theorists contend that perceptual representations play a greater role in conceptual processing than is commonly appreciated; see for example Smith and Heise (1992) and Goldstone and Barsalou (1996) for discussion.
and difference among perceived stimulus properties are represented by relative distances. Representation of perceptual values in a similarity space enables us to remember and hence recognize new instances of them, and also to associate them with useful non-perceptual information. Some such associations are probably wired in (e.g., that of increasing loudness of a sound with increasing proximity of the sound source), while others are doubtless learned (e.g., that of the orange of carrots and cantaloupe with beta carotene). As we’ll see, perceptual similarity spaces are often organized hierarchically: for example, blue and green are determinates of the determinable hue, while indigo and ultramarine are in turn determinates of the determinable blue. Thus hues can be represented as a hierarchy in which each level is more inclusive, hence more abstract, than the ones below it. In particular, within each level, values (hues) within the same determinate category are—are perceived as—more similar than values in different determinate categories. Thus different shades of indigo are more similar than any indigo is to any ultramarine.

Similarity is sometimes conceived in a broader way. For example, certain perceptual relationships among the pitches, chords, and keys of tonal music can be represented in a hierarchical space defined by relative importance or ‘stability’. The tonic pitch (‘do’) and tonic triad are heard as the most important in a key, the dominant (‘sol’) and dominant triad as the second most important, the mediant (‘mi’) and median triad third, and so forth. Pitches and chords that are relatively closer together in this hierarchy are perceived as more closely related, hence in a broad sense more similar in a given key, than pitches and chords that are farther apart. So, for example, the tonic and dominant pitches and chords in a key are more closely related, and to that extent more similar, than either is to the sub-dominant (‘Fa’). Tillman et al. (2000) write that

an important feature of Western musical grammar is that tones and chords have different structural functions within a key. According to Meyer (1956), ‘In the major mode in Western music the tonic tone is the tone of ultimate rest toward which all other tones tend to move. On the next higher level the third and fifth of the scale, though active melodic tones relative to the tonic, join the tonic as structural tones; and all the other tones, whether diatonic or chromatic, tend toward one of these’ (pp. 214–215). These differences in musical functions create within-key hierarchies (2000: 886).

Also, keys themselves stand in relations of similarity and difference, which can be represented geometrically. Again, Tillman et al.:

Some keys share numerous chords and tones. For example, the C-major key shares four chords and six tones with the G-major key, two chords and five tones with the D-major key, and only one tone with the F-major key. Keys sharing chords or tones are said to be harmonically related. The strength of these harmonic relationships depends on the number of shared chords or tones. In music theory, keys are conceived spatially as a circle, referred to as the [circle] of fifths. The number of steps separating two keys on this circle (whatever the direction of the rotation) defines their harmonic distance (2000: 886).

Hierarchical organization is thought to facilitate learning and memory of perceptual information. Similarity spaces are often structured hierarchically.

The following discussion is divided into three parts. The first part describes several specific models of visual and auditory similarity spaces—specifically, colour and pitch spaces. The second part discusses some of the interesting and often surprising ways in
which perceptual systems distort or ‘warp’ their similarity spaces. It turns out that, sometimes, in order to serve their adaptive functions, perceptual systems must in effect misrepresent the relationships among stimuli in a certain domain. We will see several vivid examples of this. Lastly, I will consider the implications of some psychological studies of hue perception for a philosophical problem about the individuation of determinate shades of colour.

2 Models of similarity spaces: Colour

The structure of colour space has received a great deal of attention from both scientists and philosophers. The overarching goal of the part of this research that interests us here is to correctly represent perceived similarities and differences among all of the colours we can see. Models of colour space typically have at least these three desiderata: (i) to isolate a set of fundamental magnitudes or dimensions (e.g., hue, brightness, and saturation, or ‘primary’ hues red, blue, and yellow) in terms of which any humanly perceivable colour can be analysed and identified, (ii) to assign to every colour a location in a geometrical space defined by those dimensions, and (iii) to determine the physical stimulus values or ranges of values associated with each colour in the space and, thereby, to discover what relationships exist between physical stimulus properties and our perceptual responses to them. Stimuli and responses are not always related systematically, but often some more or less reliable correlations can be established in terms of the responses of an idealized ‘standard observer’ under ‘standard conditions’—viz., a normally sighted person viewing stimuli of a certain size against a dark achromatic background under North Daylight, illuminated at 90 degrees, viewed at 45 degrees, etc. (I will say more about the lack of systematic correlation between stimulus properties and perceptual responses in Section 4 of this chapter.) Many models of colour space have been developed, but no single one has emerged as superior. To some extent, different models are useful for different purposes. Here I can discuss only a few of the most interesting and important ones.

The effort to construct a geometric map of colour space has a venerable history tracing back at least to Newton’s colour circle in his *Opticks* (1704). The visible spectrum itself is simply a series of single wavelengths of light that can be seen by the unaided human eye, extending from about 400 nanometres (seen as blue violet) to about 700 nm (seen as orange red). Newton realized that the two ends of the spectrum, blue violet and orange red, could be connected perceptually in a circle by the addition of three colours—red violet, magenta, and pure or unique red; but these do not occur in the visible spectrum (Figure 36.1). Interestingly, he discovered that these extraspectral hues could be produced by overlapping (‘mixing’) the blue violet and orange red spectral lights. This circular

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1 For sustained discussion of colour perception, see Akins and Hahn, this volume.
2 A reliable model is sought for commercial purposes as well as purely intellectual ones. Shared, stable standards for identifying colours are needed for gemstone evaluation, dye matching, and paint manufacturing, among other things.
3 The spectrum contains only monochromatic light, viz., light of a single wavelength. Newton’s three extra colours are produced by adding two or more wavelengths together. In particular, all spectral reds
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geometry enabled him to represent the fact that red (~700 nm) looks more similar to blue (~400 nm) than to green (~500 nm), even though the wavelengths of red and green light are closer together in the spectrum. Intuitively, there is nothing circular about the spectrum; the circularity is strictly perceptual.

In 1874, with the new science of psychophysics on solid ground in the work of Weber, Fechner, and Helmholtz among others, Ewald Hering (1892) postulated, correctly, that human colour perception was structured by three opponencies: red vs green, blue vs yellow, and light vs dark. This structure was later confirmed in a famous experiment by Hurvich and Jameson (1957), using a hue cancellation task; see Section 4.)

contain a small amount of yellow, thus requiring the addition of a small amount of yellow-cancelling blue light to obtain unique red. (Unique red is pure red containing no blue or yellow, unique blue is pure blue containing no green or red, and similarly for yellow and green.)

5 Hering mistakenly conceived of lightness and darkness as the colours white and black, which are not opponents; black is only a surface or pigment colour, not a colour of light, and white and black pigments mixed together produce shades of grey. In fact, the light vs dark (or brilliant vs dim) parameter is a genuine, though achromatic, opponency.

**FIG. 36.1** Newton’s colour circle (1704). The pulled-out section contains three extra, non-spectral colours red violet, magenta, and unique red. The seven upper-case letters around the outer rim of the circle refer to the seven pitches of the C Major scale. Newton’s belief in an important relationship between hue and pitch led him to posit the seven primary hues whose names appear in the diagram: violet, red, orange, yellow, green, blew, and indigo.

Interestingly, Hering based his theory on largely phenomenological considerations, such as the fact that we can experience a reddish yellow or reddish blue, but not a reddish green, and the fact that yellow seems (looks) as basic as red, green, or blue. However, using the technique of multi-dimensional scaling, Roger Shepard (1962) confirmed experimentally both the perceptual ordering of spectral hues around a circle and the red/green and blue/yellow opponencies. Shepard had subjects rate the similarity between members of each pair among fourteen colour chips matching spectral hues. (He excluded the extraspectral red violet, magenta, and unique red so as not to bias his subjects toward a circular geometry.) When fed into a multi-dimensional scaling program, his data produced the map in Figure 36.2, in which similarity is represented by spatial distance. The hue opponencies are evinced in the locations of opponent hues more or less diametrically opposite one another.

In 1857, Grassmann had proposed that an adequate description of a colour (as opposed to just a hue) must specify its hue, brightness (lightness or value), and saturation (chroma). This view remains standard today, and most modern colour maps plot the locations of colours along axes assigned to these psychophysical attributes in a three-dimensional space (Figure 36.3).

Since the 1920s, one of the most widely used models of colour space has been the one developed by the artist and educator Albert Munsell (1929). Munsell’s goal was to provide a ‘rational way to describe colour’ that would employ decimal notation instead of colour names, which he thought were misleading. To this end, he constructed a space in which the colours were meant to be perceptually equally spaced along the dimensions of hue, brightness, and saturation. In earlier work, Munsell had proposed a spherical colour space, but he discovered that if the colours were to be separated by perceptually equal steps, the space would have to be geometrically irregular. Just for example, there are more perceptually equal hue steps between unique red and unique blue than between unique red and unique yellow. Figure 36.4 shows an approximation of Munsell colour space after several revisions by the Optical Society of America (OSA) (Newhall et al., 1943).

![Figure 36.2](image-url)  
**FIG. 36.2** Shepard’s hue map (1962: 236), based on pairwise similarities among fourteen Munsell chips.
Another well-known framework for representing colour space, the Swedish *Natural Colour System* (NCS, introduced officially in 1979) is based on Hering's opponency theory. This model (Figure 36.5) is intended primarily to enable easy verbal communication about colours.

Here the locations of colours are determined at least in part by averaging over the judgements of many test subjects in a *magnitude estimation* task. These judgements are subjects'
estimates of the percentages of the four unique hues (pure red, yellow, green, blue), and also black and white, that are contained in non-unique test stimuli. Other approaches, such as the series of models developed by the Commission Internationale de l’Éclairage (CIE) starting in 1976, are based at least in part on the cone excitation ratios produced by the corresponding stimuli. Different ways of measuring similarities among colours (magnitude estimation, similarity ratings, cone excitation ratios, etc.) yield different representations of colour space.

Every colour model proposed thus far suffers from certain shortcomings as a representation of perceptual space. For example, the increments between neighbouring values in the Munsell map turn out not to be perceptually uniform, and to the degree that the increments are uniform, they are uniform only within single dimensions (hue, brightness, saturation); hence it doesn’t provide an ordering of colours. (Subsequent efforts by the OSA to construct a genuinely uniform colour space led to the conclusion that it couldn’t be done in three dimensions.) The NCS model misrepresents the brightness (brilliance, dimness) of colours: whereas spectral colours vary widely in brightness—for example, monochromatic yellows are brighter than monochromatic blues—the NCS model locates all of them at the same level on its vertical white/black dimension. These are just some examples.

In general, any three-dimensional model must involve an extreme, distorting simplification of the phenomena it represents. First of all, probably no single geometry can accommodate all of the different ways of measuring colour similarity and difference. But in addition, the three-dimensional models must abstract from many nonlinear relationships obtaining between physical stimulus properties and perceptual responses. Among other things, just noticeable differences (jnds) at the extremes of a perceptual dimension are larger than jnds in the middle (cf. Section 4); the value perceived on one dimension may be affected by values perceived on other dimensions (e.g., the hue of a stimulus may...
vary with its brightness and saturation), and the ways in which values on the different
dimensions influence each other may not be uniform across all hue categories. Also,
contextual factors such as stimulus size, visual surround, lighting conditions, contrast
effects, and the state of the subject’s visual system play a role in determining how a stimu-
lus looks. Cognitive factors may also enter in; for instance, a picture of a banana may be
rated as looking more yellow than an abstract shape cut from the same uniformly col-
oured piece of yellow paper.

3 Models of similarity spaces: Pitch

With the emergence of the psychology of music as a discipline starting around 1970, con-
siderable attention has been paid to mapping the pitch space of tonal music, viz., music that
has a tonal centre or key. The quasi-syntactic character of tonal music is unusual (perhaps
unique) among non-linguistic perceptual stimuli, and as such it provides a rich source of
insight into the structure of human perception and cognition. Here the perceptual space
is defined primarily by hierarchies of relative importance or stability in a scale or key or
in a specific musical work. Our mental representations of these structures are thought to
underlie, or constitute, what could be called our understanding of tonal music—for exam-
ple, our recognition of wrong notes, our surprise at deceptive cadences, our amusement at
a dominant chord left unresolved, our recognition of a return to the tonic.

In speaking just now of pitch perception I meant ‘pitch’ in the broad sense in which the
dimension of pitch is opposed to (e.g.) the temporal dimensions of metre and rhythm or
the dimension of loudness. Within the domain of pitch broadly conceived are the three
defining elements of tonal pitch space: pitches, chords, and keys, where ‘pitch’ is now con-
strued more narrowly as a count noun, as when we say that intervals contain two pitches; a
chord contains three or more pitches, and a key is a region of pitch space delineated by the
seven pitches of a diatonic scale (do, re, mi, fa, sol, la, ti).

Like hue space, pitch space is at bottom just a straight line from the lowest frequency
we can hear (about 20 hertz) to the highest (about 20,000 hertz). To model the pitch space
activated in perception of tonal music, however, we must incorporate the relation of octave
equivalence, viz., the apparent sameness (type-identity) of pitch or chroma obtaining
between pitches that are an octave apart. In that case pitch space is modelled as a circle
consisting of twelve pitch classes (Figure 36.6). (We can think of the pitch circle as con-
structed in something like the way Newton constructed his hue circle, viz., by taking a
straight line representing the twelve pitches in an octave and bringing its opposite ends
together so that they overlap. The overlap is the octave equivalence.)

Of course this pitch circle contains very little information about the myriad relationships
among the twelve pitches in an octave. Roger Shepard (1982), among others, sought to cap-
ture more of this relational information by modelling pitch space as a double helix based on
the circle of fifths; however, this structure was built on a pair of whole-tone scales, which

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6 The series of models developed by the CIE have begun to try to take a greater range of these contextual
factors into account; see for example Hunt (2004) and Fairchild (2005).
7 For further discussion see Charles Nussbaum’s entry on music perception in this volume.
play little if any role in tonal music. (Indeed, whole-tone scales tend to weaken the sense of a tonal centre.) Subsequently a variety of approaches, including statistical learning theories, music-theoretic analyses, and probe-tone and multi-dimensional scaling techniques, among others, have produced richer and more plausible models. Just for example, Carol Krumhansl applied multi-dimensional scaling techniques to data from an experimental probe-tone task\(^8\) and achieved the results shown in Figure 36.7: pitch class distance relationships within a scale or key (here, C Major) in Figure 36.7a, chordal relationships within a key in Figure 36.7b, and relationships among the twelve major and twelve minor keys in Figure 36.7c. The key relationships, structured both by the circle of fifths and the relative and parallel relationships between the major and minor keys, can be represented equivalently as points on the surface of a torus or doughnut shape. (Notice how much more information about pitch relations is captured by Krumhansl’s conical space than by the simple pitch circle. Among other things, the pitches of the tonic triad—C, E, G—cluster near the vertex of the cone, indicating that they are the most important, most stable pitches in the key of C Major.)

4 Warpings of perceptual space

The geometric nature of the models described above may give the mistaken impression that perceptual spaces are more or less regular—evenly spaced, uniformly divided, etc.—and that perceptual values are more or less systematically related to physical stimulus characteristics. Stevan Harnad writes:

The default assumption is that [psychological similarity] spaces have a fixed dimensional structure and that each dimension has a fixed and generally linear metric. Implicit in this

\(^8\) In a probe-tone task, subjects hear a stimulus (e.g., a chord or fragment of a scale or melody) followed by a short silence and then a single tone. They are asked to judge how well the probe tone ‘fits’ with the preceding stimulus.
view is the idea that any given object has a determinate location in this space and that its proximity to other items, including prototypes or other summary central tendencies, can be calculated in a straightforward fashion. The salience of various dimensions may shift as a function of category training, but the space itself is assumed to be an unchanging constant (1998: 732).

In fact our similarity spaces are somewhat irregular and unpredictable, but as we'll see, the irregularity often serves an adaptive purpose, and it must be accommodated by any adequate philosophical or psychological theory of perception.

'Warpings' or distortions of perceptual space are effected in both discrimination (same/different judgements) and categorization (type-identification); in other words, both our jnd spaces and our category spaces are warped at various places. Perhaps the most familiar warping of jnd space occurs in response compression, cited briefly above, in which jnds are larger at extremes of a perceptual stimulus range—for example, at the high and low ends of the pitch and brightness ranges—than in the middle. We have more difficulty hearing

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**FIG. 36.7** (a) Krumhansl (1979: 357) pitch class space for key of C Major. (b) Krumhansl et al. chord space within a key. (1982: 32). (c) Two-dimensional representation of relationships among the twenty-four major and minor keys (Krumhansl and Kessler 1982). If the top and bottom edges are brought together, and the left- and right-hand edges, the result is a doughnut shape or torus.
the difference in pitch between two very high frequencies or two very low frequencies than between two frequencies in the middle of the audible range; and more difficulty seeing the difference in brightness between two very brilliant lights or two very dim lights than between lights in the middle of our brightness range. These asymmetries may be biologically adaptive in that our discriminations needn’t be sharpest ‘at the edges’, as one might put it; rather, they must be at their most sensitive in the regions of perceptual space ‘where… stimuli are most densely concentrated’ (MacLeod, 2003).

An especially interesting type of warping occurs in categorical perception. In the ideal, perception is categorical when discrimination is limited by, i.e., is no finer-grained than, categorization—that is, when we cannot discriminate different values within a category. A well-known instance of this phenomenon occurs in phoneme discrimination: in a series of stimuli progressing gradually (acoustically) from ‘pa’ to ‘ba’, speakers cannot distinguish different ‘pa’ sounds or different ‘ba’ sounds. They cannot hear a gradual progression from the one phoneme to the other, even though an acoustic progression is presented; they hear only ‘pa’ and then ‘ba’, separated by a ‘pop’ rather than a gradual change (Liberman et al., 1957). This is categorical perception in the ideal, but the phenomenon is usually thought of as admitting of degrees; we can say that perception is categorical to the extent that it sustains within-category compression and between-category expansion of perceived stimulus difference. For example, hue discrimination is said to be categorical to the extent that subjects are faster and more accurate at discriminating between hues belonging to different hue categories (e.g., red and blue) than they are at discriminating between hues from the same category (e.g., two shades of red), even when the ‘within-category’ stimuli differ physically by the same amount as, or even by more than, the between-category stimuli. In short, discrimination is better between categories than within them.

In at least some cases, categorical perception too is thought to be adaptive. Pevtzow and Harnad (1997) argue that it

occurs in the service of category learning: to reliably resolve confusion at the category boundary, where uncertainty is maximal, internal representations of stimuli that are near to or on the wrong side of the category boundary must be ‘moved.’ The movement is manifested as within-category compression and/or between-category separation—whatever is needed to partition similarity space and generate reliable, all-or-none categorization. (190)

Pevtzow and Harnad note that most studies of categorical perception have focused on categories that are either innate or acquired more or less automatically by exposure. But they have found evidence that the phenomenon emerges even where the categories in question are acquired with explicit training—provided they are sufficiently difficult to learn. To show this, Pevtzow and Harnad had subjects make same/different judgements of pairs of visual texture stimuli, some easy and some difficult (Figure 36.8), and found that categorical perception occurred in the difficult cases, where stimuli were easily confused. This result supports the exciting hypothesis that categorical perception

occurs in the service of categorisation when the categorisation is neither trivially easy nor impossibly difficult; the magnitude of the separation/compression effect depends on how much the internal representations of the ‘shadows’ cast by the members and nonmembers of categories have to be ‘moved’ in order to get them on the right side of the category.
boundary ... The output of perceptual categorization is a similarity space that has been deformed in various ways to carve out the parts of the world that we need to act upon differentially and call by different names.

Once the names are grounded in perceptual ‘chunks’ which have been learned the hard way, through trial and error feedback, those names become available for another form of representation and another means of learning new categories: Names can be strung together in the form of propositions that define further categories (Harnad 1996, Cangelosi and Harnad, in preparation). This unique way of acquiring categories is what sets us apart from other species (Pevtzow and Harnad, 1997: 194).

A different kind of warping is evident in a striking result obtained by Shepard and Jordan (1984). They constructed an equalized octatonic scale, i.e., a sequence of eight pitches separated by logarithmically equal increments of frequency, spanning an octave. Then they instructed subjects to judge of each successive pair of these pitches (1–2, 2–3, 3–4, etc.) whether the increment between the two pitches was smaller than, larger than, or the same as, the increment between the preceding two. Logarithmic (ratio) equality normally ensures perceptual equality, but in this case, subjects heard the physically equal ratios as varying in size; specifically, the 3–4 and 7–8 increments in the equalized scale were heard as being larger than the others. Shepard and Jordan explain this result by proposing that listeners have a stored mental schema or template of a diatonic musical scale, in which the sequence of steps is whole tone (1–2), whole tone (2–3), semitone (3–4), whole tone (4–5), whole tone (5–6), whole tone (6–7), semitone (7–8). Their thought is that the 3–4 and 7–8 steps in the octatonic stimulus, ‘though physically equal to the others, [were] judged larger

Fig. 36.8 Pevtzow and Harnad (1997: 190) discrimination stimuli.

9 In this connection, see Gary Hatfield’s entry on nineteenth-century psychology, in this volume.
because [they were] wide in relation to the narrower [semitone] gaps “expected” by the input template’ (1984: 1333). What’s especially fascinating about this result is that the diatonic scale is a mere cultural artefact. Among other things, it was created, presumably for artistic purposes, by compressing (tuning slightly flat) the perfect fifth intervals so that they equal 3½ tones. This enables the fifths to fit properly into the octaves, thereby permitting modulation from any of the twenty-four major and minor keys to any other. Evidently, although it is an artefact, the structure of the diatonic scale is so deeply etched into the acculturated mind that Shepard and Jordan’s subjects could not hear the physically equal steps as equal. Their pitch space had been warped by it.

5 A PHILOSOPHICAL IMPLICATION: IDENTITY CONDITIONS FOR DETERMINATE SHADES

The idea of determinate hues or shades of colour, viz., the finest shades we can discriminate, is generally taken by philosophers to be both uncontroversial, indeed commonsensical, and incoherent. It is taken to be commonsensical because it is commonsensical: every red object is some particular shade of red, indeed every magenta object some particular shade of magenta. It is taken to be incoherent because identity conditions for determinate shades would have to be given in terms of a relation of indiscriminability, so the story goes, and indiscriminability is non-transitive. In a classic discussion, Christopher Peacocke says:

It is pretheoretically tempting to suppose that . . . perceived shades s and s’ are identical if and only if s is not discriminably different from s’. The nontransitivity of nondiscriminable difference (“matching”) entails that there is no way of dividing the spectrum into shades that meets that condition. Take an example in which, in respect of colour, x matches y, y matches z, but x does not match z. To conform to the above principle about shades, the shade of y would have to be identical to shades that are distinct from one another (1992: 83).

And Matthen writes:

Strictly speaking, the notion of a fully determinate shade is logically defective since, as Peacocke 1987 points out, the relation of sensory indiscriminability is intransitive . . . (2005: 101).

Let me make several points here. Even setting aside doubts about the supposition that indiscriminability is non-transitive, why think that determinate shades (hues) can be defined only in terms of indiscriminability? Results of some psychophysical experiments suggest at least one other feasible way to define them—viz., in terms of some form of hue cancellation or magnitude estimation. In a hue cancellation task, the subject adjusts the amounts of coloured light in a target light until she arrives at a unique hue. For example, if the target is originally blue-green, she will add red light to obtain a unique blue, or yellow

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10 The inequality of step sizes is essential to the establishment of a tonal centre.
11 When in tune, i.e., not compressed, a perfect fifth is slightly larger than 3½ tones.
12 For some of the doubts, see e.g., Raffman (2000, 2011, 2012), Graff (2001).
light to obtain a unique green. By measuring the amount of red or yellow she adds, the experimenter then learns the percentages of green or blue that she perceived in the original stimulus; for instance, she might have seen the original blue-green light as containing 70 per cent blue and 30 per cent green. Hue cancellation can be contrasted with the more difficult task of magnitude estimation, in which the subject has to estimate those percentages, simply by inspection, in a presented stimulus.

It seems plausible, and I suggest, that determinate shades can be identified by their percentages of the four chromatic components red, blue, yellow, and green. In fact we know already that the four unique hues can be identified quite reliably in this way, as 100 per cent red, 100 per cent blue, 100 per cent yellow, and 100 per cent green. The perfectly balanced binary hues—orange, violet, blue-green, yellow-green—contain 50 per cent of each component; red-orange might be 75 per cent red and 25 per cent yellow, and so on. Of course the extent of our ability to identify or categorize colour stimuli in this way cannot be unlimited: for example, presumably we cannot recognize as such a shade that is 43 per cent blue and 57 per cent green, as opposed to one that is 44 per cent blue and 56 per cent green—much less 43.5 per cent blue and 56.5 per cent green, etc. But absent independent reason to think that our experiences of non-unique, non-balanced determinate hues are relevantly different from our experiences of the unique hues and balanced binaries, we can plausibly take our experiences of the former to be of a kind with our experiences of the latter, and regard them as similarly type-identifiable at least in principle. (Of course there will be, and need be, no perfect correlation between perceived values and physical stimulus properties. What I’m proposing is a way to individuate and recognize perceived values—phenomenal appearances, if you like—not to discover any such correlation.)

If the foregoing proposal is adequate, then as far as the individuation of determinate shades is concerned, it doesn’t matter whether indiscriminability is non-transitive. The behaviour, indeed the coherence, of the indiscriminability relation remains a puzzle, but contrary to received wisdom, that fact needn’t threaten the notion of determinate shades.

References


