Timaeus on Color Mixture

Perception, for Timaeus, is a kind of measurement. What Timaeus describes as παθήματα—affections of the body as a whole (61d5–65b3) or in part (65b4–68d7) that are liable to produce perceptions or sensations—are the measure of the sensible objects that produced them, and perception is the cognizance of what is measured, not the affections, but the objects that produced these affections.[1] In the present essay, we shall consider only a restricted version of this more general claim. Specifically, we shall see how the affections of the complex visual organ are the measures of the colors that cause them.

In the initial discussion of vision (45b2–45d6), Timaeus says nothing specific about the colors that produce visual affections, nor does he say anything specific about the nature of these affections. With respect to the auxiliary causes of vision,[2] Timaeus largely confines himself to the construction of the visual body, ὄψις,[3] that is the primary—though, significantly, not the sole—recipient of affection in the causal process eventuating in visual perception. Specifically, Timaeus claims that the eye contains a fire within that is emitted through the pupil owing to its fineness (45b6–c2), and that this fire combines with daylight, akin to it (ἀδελφόν, 45b6), to form a body that may be acted upon as a homogenous unity (συμπαγὲς γενόμενον, ἓν σῶμα,45c1–6) and uniformly affected (ὁμοιοπαθές, 45c7). The

[1] All references to the *Timaeus* are from J. Burnet, *Platonis Opera* 4 (Oxford, 1962).

[2] On auxiliary causes see S. Strange, 'The Double Explanation in the *Timaeus*', *Ancient Philosophy* 5 (1985), 25–39.

[3] On the translation of ὄψις as visual body see K. Ierodiakonou, 'Plato's Theory of Colours in the Timaeus' ['Plato's Theory'], *Rhizai* 2 (2005), 219–233 at 221–2.

present difficult passage (67c4–68d7)[4] completes Timaeus' account of the auxiliary causes of vision. For, here, we are told about the colors that cause visual affections, and we are told how the visual body is affected by the colors. In the next section, we shall consider some general claims about the colors before considering their effects on the visual body and the eye from which it issues.

1. Color, Fire, and Flame

Colors consist in a kind of flame, and since the visual body consists in the fire emitted from the eye combined with the fire that constitutes daylight, each a mild light that does not burn (45b4–6), three fires of two kinds are involved in seeing the colors of things. Ierodiakonou distinguishes three claims that Timaeus about the colors:[5]

(1) colors consist in kind of fire, a flame (φλόξ)

(2) colors consist in effluences that emanate from bodies

(3) colors are perceptible if the effluences are proportional with the visual body

[4] For discussion of these difficulties see T.H. Martin, *Études sur le Timée de Platon* (Paris, 1841), 294; A.E. Taylor, *A Commentary on Plato's Timaeus* [*Commentary*] (Oxford, 1928), 479–92; and F.M. Cornford, *Plato's Cosmology, The Timaeus of Plato* [*Cosmology*] (London, 1935), 276–8.

[5] Ierodiakonou, 'Plato's Theory', 221.

Before discussing these, allow me to make a preliminary observation concerning the potential influence of Empedocles.[6] While Archer-Hind denies that Timaeus' account of color is Empedoclean, Taylor, especially in light of the second and third claims, insists that it is (as does Theophrastus, *De sensibus* 91).[7] While I agree with Taylor that the influence of Empedocles is clear, Timaeus' account is not straightforwardly Empedocles'. As we shall see there are notable differences, making Archer-Hind's denial plausible if misleading.

First, Timaeus claims that color consists in kind of fire, a flame, φλόξ (67c6). Timaeus claims that there are many kinds of fire but only offers three examples (58c5–d1). First, there is flame, φλόξ. Second, there is the kind that issues from flame but does not burn but

---

[6] For discussion of Empedocles' account of vision see A.A. Long, 'Thinking and Sense-Perception in Empedocles: Mysticism or Materialism', *The Classical Quarterly* 16 (1966), 256–276; D. Sedley, 'Empedocles' Theory of Vision and Theophrastus' *De Sensibus*' in W.W. Fortenbraugh and D. Gutas (eds.), *Theophrastus: His Psychological, Doxographical and Scientific Writings* (New Brunswick, 1992), 20–31; K. Ierodiakonou, 'Empedocles on Colour and Colour Vision' ['Empedocles'], *Oxford Studies in Ancient Philosophy*, 29 (2005), 1–38; Kalderon, *Form*, ch. 1; and P. Curd, 'Empedocles on Sensation, Perception, and Thought', *History of Philosophy & Logical Analysis* 19 (2016), 38–57.

[7] R.D. Archer-Hind, *The Timaeus of Plato* [*Timaeus*] (London and New York, 1888), 248 n3; Taylor, *Commentary*, 480. For criticism of Theophrastus see G.M. Stratton, *Theophrastus and the Greek Physiological Psychology before Aristotle* [*Theophrastus*] (New York, 1917), 220 n239. On Archer-Hind's denial see J. Cook Wilson, *On the Interpretation of Plato's Timaeus, Critical Studies with Special Reference to a Recent Edition* [*Interpretation*] (London, 1889), 21 and 43–6. For a recent discussion, see Ierodiakonou, 'Plato's Theory'.

supplies light to the eyes. And third, there is the kind that is left behind in embers after the flame is quenched. The fire that constitutes the light of day is explicitly claimed to be of the second kind (45b4–6). Presumably, the fire emitted by the eye is as well since Timaeus claims that it is akin (ἀδελφόν) to daylight (45b6), a mild light that does not burn (45b4).[8] And if that is right, then the compound of fire and daylight, the visual body, belongs to this second kind as well. However, color is said to consist in a different kind of fire, flame, φλόξ (67c6). Color is not a mild light that does not burn but a flame that burns. Like does not act upon like (57a3–5). And presumably it is this specific difference in the fires of color and the visual body that allows the former to act upon the latter.

Second, colors consist in effluences that emanate from bodies (67c6). This is a clear allusion to the account that Socrates attributes to Empedocles in the *Meno* (76d4–5), an attribution seconded by Theophrastus in *De sensibus* 7.[9] Within Timaeus' cosmology, the effluences are kind of primary body, tetrahedra of fire, the molecular components of secondary bodies such as a visible fire. So fiery tetrahedra emanate from colored bodies. The claim that colored bodies emit fiery effluences is weaker than the identification of colors with effluences or perhaps streams of them. Does Timaeus follow Empedocles in

[8] I hedge only because Timaeus stops just short of making this claim explicit. It is nonetheless plausible that the fire within the eye is mild and does not burn since, if it did, the eye would be damaged.

[9] On the legitimacy of that attribution see H. Diels, 'Gorgias und Empedokles', *SB Berlin* (1884), 343–68. For a more recent discussion see D. Sansone, 'Socrates' "Tragic" Definition of Color (Pl. Meno 76D–E)', *Classical Philology*, 91 (1996), 339–45.

identifying colors with effluences? He seems to when he claims that colors are flames that stream off bodies (67c6–7).[10]

Third, colors are perceptible only if the chromatic effluences are proportional with the visual body (ὄψει σύμμετρα, 67c7). Though clearly inspired by Empedocles, Timaeus' position is really the converse of Empedocles'. While Timaeus retains Empedocles' Eleatic conviction that sense objects are proportional to sense, they differ in how the relevant proportion is implemented in the sense object's interaction with sense. According to Empedocles, only effluences commensurate with the passages (πόροι) are perceptible.[11] If an effluence is too large or too small to fit, and so incommensurate in size, then it fails to excite perception. However, according to Timaeus, only particles incommensurate in size with the visual body excite perception. If the particles are smaller than the visual body, then they divide it to give rise to a perception of white (67e5). And if the fire particles are larger than the visual body, then they compact that body so as to give rise to a perception of black (67e4). Particles commensurate with the visual body, on the other hand, do not affect the

---

[10] Φλόγα τῶν σωμάτων ἑκάστων ἀπορρέουσαν. A reading accepted by Ierodiakonou, 'Plato's Theory', 221. I am uncertain. One consideration against attributing the Empedoclean identification to Timaeus, while minor, is suggestive. The effluences are primary bodies. But only secondary bodies compounded of primary bodies are sensible. We may see a visible flame, but we do not see the individual tetrahedra that compose it. But as P.F. Strawson, *The Bounds of Sense: An Essay on Kant's Critique of Pure Reason* (London, 1966), 109, observes, 'colours are *visibilia* or they are nothing.'

[11] Plato, *Meno* 76d4–5, Theophrastus, *De Sensibus* 7. For discussion see Ierodiakonou, 'Empedocles', 20–5.

visual body and so are insensible and are called 'transparent' (διαφανῆ). So, while Empedocles claims that only commensurate particles excite perception, Timaeus' view is that only incommensurate particles excite perception. Rather than reduplicating the Empedoclean scheme, Timaeus' account of vision involves the converse proportion between the size of the chromatic particle and the relevant part of the visual sense organ. A point missed by most commentators. On the hypothesis of Empedoclean influence, this is both puzzling and significant.

There is another notable difference from Empedocles' account of vision. According to Empedocles, white and black are distinguished by the elemental composition of these effluences.[12] White effluences are composed of fire and black are composed of water.[13] Timaeus, on the other hand, distinguishes white from black, not by a difference in their elemental composition, but by the size of the fire particles and their different effects on the visual body. Though, as we shall see, the dark waters of the eye do play a role in Timaeus' account of color perception, if not the role that they play in Empedocles' account.

The Timaean inversion of the Empedoclean scheme is now explicable. According to Empedocles, the perception of a given color is determined by the proportion of fire and water effluences that it takes in. In declining to understand white and black in terms of the elemental composition of chromatic effluences, Timaeus needs two affections that correspond to the taking in of fire and water. These turn out to be division (διάκρισις) and

---

[12] Ierodiakonou, 'Plato's Theory', 223, and 'Empedocles'.

[13] See Theophrastus, *De sensibus* 7. See also Plutarch's commentary on Empedocles DK 31B94 in *Historia naturalis* 39, B. Inwood, *The Poem of Empedocles, A Text and Translation with an Introduction* (Toronto, 2001), CTXT-87 137–8.

compaction (σύγκρισις). But division requires the agent of division be smaller than what it divides, just as compaction requires the agent of compaction be larger than what it compacts. And this has the result that only incommensurate effluences excite perception, whereas for Empedocles only commensurate effluences excite perception.

Color perception, for Timaeus, is a kind of measurement. Colors are perceptible only if the chromatic effluences are proportional to the visual body. The connection between being proportional to the visual body (ὄψει σύμμετρα 67c7) and visibility is key here. The visual body is a recipient of the chromatic effluences' effects. What these effects are depend upon the proportion of between the chromatic effluence and the visual body. Thus, for example, if the chromatic effluence is larger than the visual body, it will compress that body. Whereas if it is smaller, it will divide it. In the former case, compression measures the largeness of the tetrahedra that acted upon the visual body and the size of the tetrahedra corresponds to the color of the body that emanates it. And what is thus measured is reported to the *phrónimon*, the seat of cognizance (64b5), and so cognized. In this way is the chromatic affection the measure of the color that produced it.[14]

---

[14] L. Brisson, 'Plato's Theory of Sense Perception in the Timaeus: How It Works and What It Does' ['Theory'], *Proceedings of the Boston Area Colloquium in Ancient Philosophy*, 13 (1997), 147–76 at 155–6, argues that Timaeus conceives of perception generally as a kind of measurement and emphasize the role of σύμμετρα in Timaeus' account. If Brisson is right, then Aristotle's claim, in *Metaphysics* 10 1, 1053a31–b4, that knowledge and perception are measures of things, is potentially of Timaean provenance. In a recent book, *Mind and World in Aristotle's De Anima*, S. Kelsey explores, among other things, the measurement conception of perception as it occurs in *De anima*.

There is a connection with naming here.[15] Timaeus names sense objects after the affections they induce in the sentient body (65b4–6). For example, in the case of the visible, if we are dazzled (μαρμαρυγῆ), we give a corresponding name to that which dazzled us 'bright' (λαμπρός) or 'brilliant' (στίλβος) (68a6–b1).[16] If Timaeus is indeed modelling perception on measurement, then his explanation of the names of the agents that cause the affections is both natural and intelligible. Specifically, if the affections are the measure of what caused them, it is natural that the names of the affections should apply to the causes they measure as well. Consider, by way of example, our names for temperatures.

2. Chromatic Affections

Consider now, not colors, but their effects, the chromatic affections (παθήματα). The primary (if, significantly, not the sole) recipient of chromatic affections is the visual body. There are two fundamental kinds of affections of the visual body, *diákrisis* and *súnkrisis*.

---

[15] On the importance of naming in the *Timaeus*, see D. O'Brien, *Theories of Weight in the Ancient World* 2 (Paris and Leiden, 1984), 147–52. Naming, O'Brien observes, is cosmologically significant: In the pre-cosmic chaos nothing that has a name was in a state fit to be named (69b6–7) and this is remedied by the Demiurgic imposition of form and number (53b5).

[16] Other instances of naming in connection with vision include the following passages: That which divides the visual body and that which compacts it are to be called 'black' and 'white', respectively (67e5); A mixture of fire and water is what we call a 'tear' (68a2); We call that which gives rise to a sanguineous appearance 'red' (68b4–5).

Timaeus explicitly tells us that the affections at work in our experiences of white (λευκός) and black (μέλας) respectively are the same affections at work in our experiences of hot and cold (61d5–62a5) and astringent and harsh (65c1–d3). Though these affections are the same, they give rise to distinct perceptions and sensations because they differ in their causes (67e2–4, and presumably, they are received in different parts of the body due to this difference in cause). These terms are usually translated as dilation and contraction, respectively. However, as applied to aggregates of natural bodies, *diákrisis* is more naturally understood not as dilation but as a kind of division or dispersal, and as applied to aggregates of natural bodies, *súnkrisis* is naturally understood as compaction.[17] As we have observed, the size of the fiery effluences determines their effect on the visual body. If the fire particles are smaller than the fire particles that compose the visual body, then they divide the visual body. And if the fire particles are larger than the fire particles that compose the visual body, then they compact the visual body. These affections, division and compaction, are naturally opposed as are the power and activity of the agents that produced these affections. Timaeus calls 'white' (λευκός) that which divides the visual body and 'black' (μέλας) that which compacts the visual body. This is why white and black are the fundamental chromatic opposition. Presumably this is why Taylor claims that, for Timaeus, white and black are the primary colors.[18]

---

[17] D. Hahm, 'Early Hellenistic Theories of Vision and the Perception of Color' ['Early Hellenistic Theories'] in P.K. Machamer and R.G. Turnbull (eds.), *Studies in Perception: Interrelations in the History of Philosophy and Science* (Columbus, 1978), 60–95 at 72, n47.

[18] Taylor, *Commentary*, 480–1. These definitions reoccur in Aristotle, *Topica* 3 5, 119a30, *Metaphysica* 10 7, 1057b, and Philoponus, *In Aristotelis Physicorum* 688.10.

The transparent (διαφανῆ) is a special case. If the fire particles are commensurate with the visual body, then they neither divide nor compact it but simply have no effect and hence are insensible. This is an instance of the more general principle that like does not affect like (57a3–5).[19]

From what Timaeus has told us about white, black, and transparent and their affections or lack thereof, we can establish that the visual body is not the sole recipient of chromatic affections. For suppose it were. Division and compaction are the two affections associated with the opposed extremes. Moreover, smaller tetrahedra divide the visual body, larger compress it, and like-sized have no effect. A tetrahedron is either smaller, larger, or the same size as the visual body. There are no other options. The affections of the visual body alone only give rise to the experiences of white, black, and transparent.[20] But even by Timaeus' lights, we see more colors than these. The perception of other colors must involve some further affections whose recipient is other than the visual body. As we shall see with brilliant and red, the causal process eventuating in their perception involves not only the division of the visual body as a primary effect, but the character of the resulting experience is due, as well, to subsequent secondary effects.

3. Primary Colors

[19] For discussion see Ierodiakonou, 'Plato's Theory', 225.

[20] Hahm, 'Early Hellenistic Theories', 74. Perhaps this observation motivates L. James, *Light and Colour in Byzantine Art* [*Light and Colour*] (Oxford, 1996), 57, to claim that brilliant and red are not in the brightness ordering between white and black.

Depending upon the size of the fire particles, they either divide, or compact, or have no effect on the visual body. Division and compaction are the fundamental affections involved in vision. Moreover, they are naturally opposed. Since white bodies divide the visual body and black bodies compact it, white and black were reckoned to be the primary colors. Taylor concurs.[21] This is controversial, however. Thus, Brisson and Ierodiakonou claim that there are four primary colors, not only white and black but red and what Timaeus calls 'bright' (λαμπρός) or 'brilliant' (στίλβος).[22] (Democritus also posits four primary colors: white, black, red, and green.)[23] Cornford, by contrast, claims that there are only three. Given the puzzling nature of the brilliant, he discounts it as a color.[24]

The philosophical reason for counting white and black as the primary colors in the Timaean color scheme is that they are the fundamental chromatic opposition. Sense objects, with the exception of odors, have a place within an oppositional structure. Thus, hot is opposed to cold and all other temperatures are arrayed as proportionate intermediaries between these (61d5–62a5). Not all oppositional structures are one–one. The oppositional structure involved in taste is one–many. Thus, sweet stands opposed, in different ways, to all the other flavors (65b4–66c7). Odor is the exception (66d1–67a6).

---

[21] Taylor, *Commentary*, 480–1.

[22] Brisson, 'Theory', 171–3 and Ierodiakonou, 'Plato's Theory', 227.

[23] Theophrastus, *De sensibus* 73–5.

[24] Cornford, *Cosmology*, 277. Taylor, *Commentary*, 481, also discounts brilliant as a color but gives no explicit reason for this (he thinks that it is somehow obvious from the confusion of the dazzling experience).

Understanding why remains controversial. For sense objects that figure in an oppositional structure, their sensory character is given by their place in that oppositional structure. To be lukewarm is to be midway between hot and cold. So, if white and black are the fundamental chromatic opposition, with all other colors arrayed as proportionate intermediaries, then this tells us something about the sensory character of the colors.

There are, however, additional historical reasons for this claim. This interpretation of the Timaean color scheme is in line with an ancient tradition that includes Homer, Parmenides, and Empedocles before Plato, and Aristotle and Goethe after.[25] Moreover, there is a general tendency in Greek color vocabulary to emphasize brightness over hue.[26] As supporting evidence this is pretty weak, admittedly. However, there is a further bit of historical evidence that is puzzling, at the very least. Theophrastus objects that Democritus posits four primary colors but earlier thinkers posit only two, white and black (*De sensibus* 79). What is puzzling is that Theophrastus makes no similar complaint about Plato (though, to be fair, Theophrastus, *De sensibus* 86, omits red and counts brilliant as a species of white

---

[25] On Homer see Gladstone, *Studies on Homer and the Homeric Age* [*Studies*], volume 3 (Oxford, 1858), on Parmenides see Kalderon, *Form*, ch. 5.3, on Empedocles see Ierodiakonou, 'Empedocles' and Kalderon, *Form*, ch. 5.4, and on Aristotle see R. Sorabji, 'Aristotle, Mathematics, and Colour', *The Classical Quarterly*, 22 (1972) 293–308 and Kalderon, *Form*, ch. 6.

[26] See Gladstone, *Studies*, M. Platnauer, 'Greek Color-Perception' ['Color-Perception'], *The Classical Quarterly*, 15 (1921), 153-162, H. Osborne, 'Colour Concepts of the Ancient Greeks', *British Journal of Aesthetics*, 8 (1968), 269-283, G.E.R. Lloyd, *Cognitive Variations* (Oxford, 2007), ch. 1.

in his report of the *Timaeus*).[27] Theophrastus' complaint, if cogent, crucially depends on the Democritean four-color scheme being inconsistent with the ancient view that takes white and black as the fundamental chromatic opposition. On that view, white and black are the opposed extremes between which all other colors are ordered as intermediaries. But according to Democritus, as Theophrastus understands him, white and black are insufficient to generate such an ordering since two further colors are required to generate all the colors. Thus, Theophrastus, like Taylor after him, must hold that there are only two primary colors in the *Timaeus*.

I suspect that these seemingly competing interpretations may be reconciled. Indeed, they are driven by distinct if potentially complementary ideas. Theophrastus and Taylor are moved by the idea that white and black are the fundamental chromatic opposition, that they are the opposed extremes between which all other colors are arrayed. Brisson and Ierodiakonou are moved by the idea that white, black, red, and brilliant are mixed to generate all the other colors. Even if being an opposed extreme of a sensory opposition entails being unmixed, the converse entailment fails, so being an opposed extreme and being unmixed are non-equivalent notions. So perhaps there is no real inconsistency here. Showing exactly how, within the framework of the *Timaeus*, there is no inconsistency will be one of the remaining tasks of the present essay. I maintain that Timaeus subscribes to the older tradition, and that his account of color mixture can be read as an attempt to interpret the Democritean four-color scheme in a manner consistent with white and black being the

---

[27] On Theophrastus' complaint see A.A. Long, 'Theophrastus' *De sensibus* on Plato' in Kalgra et at. (eds.), *Polyhistor: Papers Offered to J. Mansfeld on the Occasion of His Sixtieth Birthday* (Leiden, 1996), 345–62 and Ierodiakonou, 'Plato's Theory'.

fundamental chromatic opposition. To get this into view, let us begin by discussing the two other candidate, primary colors, brilliant and red. As we shall see, while brilliant and red are unmixed, the affections involved in seeing them involve both division and compaction, the affections associated with the fundamental chromatic opposition, white and black.

4. Brilliant

Like white (λευκός) bodies, bright (λαμπρός) or brilliant (στίλβος) bodies emit fire particles that divide the visual body. However, the fire particles emitted by brilliant bodies differ in kind and are more rapid than the fire particles emitted by white bodies (67e6–8). Timaeus does not specify what this difference in kind consists in, but presumably it is a difference in the size of the tetrahedra. And since the tetrahedra emitted by brilliant bodies are more rapid than the tetrahedra emitted by white bodies, presumably they are smaller, since the smallness of polyhedra contribute to the speed of their motion (55d7–56b3). The fire particles emitted by brilliant bodies also differ in their effects. Unlike the fire particles emitted by white bodies, the fire particles emitted by brilliant bodies divide the visual body all the way up to the eye where they produce secondary effects.

Before considering the secondary effects of the fire particles emitted by brilliant bodies, let me pause to make an observation since it signals a further difference between Timaeus' account and Empedocles'. For Empedocles, the effluences must enter passages in the eyes in order to excite perception. But Timaeus does not claim that the fire particles emitted by white bodies divide the visual body all the way up to the eyes. They are not claimed to enter the passages in the eyes. In the case of seeing white things, the affections (παθήματα) are affections of the visual body that is external to the eyes. Though, of course,

the visual body, as a whole, passes on this affection through the passages of the eyes so that what produced it may be reported to the *phrónimon*, the seat of cognizance (64b5), but this is not the reception of an effluence but the reception of its effect.

Observe how this has consequences for how Timaeus is conceiving of chromatic brightness. The chromatic brightness of perceived body does not correspond to the amount of fire taken into the eye as a result of perceiving it. If perceived chromatic brightness were explained in this way, then brilliant would be the brightest perceived color, followed by red and followed, finally, by white. But if white is an extreme of the fundamental chromatic opposition, then it must be the brightest color. So Timaeus must understand perceived chromatic brightness in terms other than the amount of fire taken into the eye.[28]

The fire particles emitted by brilliant bodies enter the eye. As they do, they pass the fire particles that the eye is itself emitting and penetrate and dissolve the very passages from which these are emitted. This would only be possible if there is no exact fit between the fire particles and the passages in the eye, just as there is no exact fit between the odorous particles and the blood vessels in the nostrils (66d–67a6) as Vlastos long ago

[28] I thus disagree with James, *Light and Colour*, 54, when she writes: 'Plato's underlying assumption seems to be that the higher the degree of access between the object and the eye, the brighter the colour.' (Hahm earlier endorsed a similar view, 'Early Hellenistic Theories', 73–4.) But, if the eye takes in more fire in the experience of white than in experience of brilliant, then why does the fire damage the tissues of the eye in the case of the dazzling experience of brilliant but not in the case of the experience of white? What makes for brightness is division, not degree of penetration nor amount of fire received.

observed.[29] In the eye, the incoming fire particles encounter water. This has two effects, only the second of which is relevant to visual phenomenology:

(1) the incoming fire particles cause a volume of water and fire to pour from the eye (68a2)

(2) the incoming fire particles are mixed with the water in the eye (68a1) causing all kinds of colors to appear (68a5–6)

The first secondary effect, the pouring forth of a volume of water and fire, is called 'tears'. Though a vital affection, unlike trembling's contribution to our sense of coldness,[30] the production of tears does not contribute to the dazzling visual experience. It is epiphenomenal to the causal process that elicits that experience. In this way it contrasts with the second effect. When the incoming fire is mixed with the eye's moisture, this mixture causes all kinds of colors to appear. Apparently, in a striking anticipation of Newton's discovery (*Opticks* 1), the stream of incoming fire is refracted in the water of the eye (compare Aristotle's claim that a weak light shining through a dense medium will cause

[29] G. Vlastos, 'Plato's Supposed Theory of Irregular Atomic Figures', *Isis* 58 (1967) 204–9.

[30] In his account of hot and cold (61d5-62a5), the affection of the body that gives rise to the sensation of cold is complex and involves not only the compaction of the body (a common enough thought in antiquity, compare Plutarch's report of Anaximenes in *De primo frigido* 7 947f–48a = DK 13B1) but also a vital response to that compaction, shivering, which contributes to the felt sensation of coldness. I can attest that one thing that Michigan winters taught me is that relaxing your shoulders, and thus not shivering, lessens the degree of felt coldness.

all kinds of colors to appear, *Meterologica* 1 5, 342b5–8). The resulting visual experience is called ʾdazzlingʾ (μαρμαρυγῆ) and what produced it is called ʾbrightʾ (λαμπρός) or ʾbrilliantʾ (στίλβος).

The incoming fire particles dissolve and so destroy, at least in part, the passages in the eyes (68a1). Though Timaeus does not make this explicit, this is a departure from the natural state of the eye and is presumably painful (think of staring at the sun). Pain results when the natural state of the body is suddenly and violently disturbed (64d1–3). The disruption of the visual body may not be painful since no violent effort is required to do so, but what is dissolved, here, is not the visual body issuing from the eyes but the passages of the eyes from which the visual body issues.[31] These are composed of particles greater than the particles of fire that compose the visual body and so require violent effort to dissolve. Recall, too, that while the fire in the eyes is a mild light that does not burn, the incoming fire is, instead, a flame (67c6) that burns (58c5–d1). This explains the damage inflicted by seeing brilliant bodies. The dazzling experience of brilliant bodies thus approaches the traumatic experience undergone by the Cyclops as Odysseus blinds him by inserting fire in his eye. Not only are both experiences destructive and painful, but each is a kind of blinding since when dazzled it is difficult to see the details of the scene before one.[32]

---

[31] Cornford, *Cosmology*, 269.

[32] In Euripides' satyr play, *Cyclops* 462, Odysseus, in a cruel irony, describes his plan to blind the Cyclops with a fiery brand by saying that the Cyclops' eye shall be truly light-bearing (see R.A.S Seaford, *Cyclops of Euripides*, London, 1984, 489-90 for discussion). Notice that the irony only gets a grip against the background of some view (like the one expressed by Empedocles' lantern analogy, *De sensu* 2, 437b27–438a3 = DK 31B84) that the eyes anyway

Cornford pronounces brilliance to be puzzling.[33] All kinds of colors are said to appear in a dazzling visual experience and yet in the next breath Timaeus describes bright or brilliant as a single color. Cornford's puzzle is a chromatic version of the *aporia* about the one and the many (many colors are said to appear, and yet they are meant to be the appearance of one color). Cornford's puzzle is mitigated somewhat if we turn our attention away from flat opaque colors presented against neutral backgrounds (such as how they are presented on Munsell color chips) and consider, instead, the metallic green of a beetle. Such colors have a metallic sheen that varies with the angle of incidence of the light and yet are a distinctive unitary color. How this is so may remain puzzling, but that this is so is not.[34]

Both white and brilliant divide the visual body, but what distinguishes brilliant from white is not this affection but a secondary effect, the mixing of fire and water in the eye. In

---

bear light, though perhaps not in the way that the Cyclops' will. This is a view that Timaeus shares not only with Empedocles, but also Alcmaeon of Croton (see J.I. Beare, *Greek Theories of Elementary Cognition* [*Elementary Cognition*], Oxford, 1906, 11–13), and it was widely enough held to be the basis for Euripides' irony in his satyr play. As T.K. Johansen keenly observes in *Plato's Natural Philosophy*, (Cambridge, 2004), 114, Timaeus (45b3) uses a variant of vocabulary employed by Euripides (*Cyclops* 462 and 611) when he claims that the eyes that the Young Gods affix to the face are light-bearing, φωσφόρα ὄμματα (vocabulary notably not employed by Empedocles in the lantern analogy).

[33] Cornford, *Cosmology*, 277–8.

[34] Modern colorimetrists posit extra dimensions of color similarity to explain such phenomena. M.D. Fairchild, *Color Appearance Models* (West Sussex, 2005), for example, lists five dimensions of color similarity.

the case of the dazzling, the affection, as a whole, includes not only division but this mixture as well. Seeing white involves an affection produced by fire alone, a dazzling experience involves, in addition, an affection produced by fire and water. While the fire that elicits a dazzling experience may be great in amount, its mixture with water involves a reduction of chromatic brightness, understood as a dimension of color similarity, with the effect that all kinds of colors appear and not all of which are white. Mixing with the eye's water darkens.[35] Perhaps it does so by compacting the incoming stream of fire particles that mixes with it, in which case the water of the eye is black.

There is an ancient tradition that assigns black as the color of water. (Not to be confused with the claim, also held by many in this tradition, that water makes things black generally, or that darkness itself is a moist substance.) Thus, Anaxagoras (DK 59B15), Empedocles (DK 31B94, Theophrastus, *De sensibus* 59, Plutarch, *Historia naturalis* 39), and later Aristotle (*Meteorologica* 3 2, 374a2) all held that water is black. If Timaeus subscribes to this ancient tradition, then the affections caused by brilliant bodies involves both division and compaction.

A trace of Timaeus' adherence to this tradition can, in fact, be found in the text of his speech at 60d 2–4. There, Timaeus explains the color of blackened earthenware in terms of the presence of water in its composition, retained, somehow, throughout its firing.

---

[35] On the eye's waters darkening the incoming stream of chromatic fire thus causing all kinds of colors to appear, see Taylor, *Commentary*, 482. Timaeus describes what transpires when a small amount of fire is surrounded by the other primary bodies (56e2–7). Perhaps something similar transpires when the chromatic fire is surrounded by the waters of the eye.

Moreover, Timaeus links water with darkness when he claims that the opaque kind of air is called 'mist' (ὀμίχλη) or 'darkness' (σκότος) (58d1–4). If water is black, then the presence of water in the composition of body may explain why it is black. But that is not yet to claim that all blackness is explained by the presence of water. And we have seen that Timaeus rejects Empedocles' claim that white and black effluences are to be understood in terms of their elemental composition. It is not so much that Timaeus thinks that the dark is wet, but, rather, he thinks that water is dark.

The chromatic affection involved in the dazzling experience of brilliant is complex. It involves not only the division of the visual body but also two secondary effects: (1) tearing and (2) mixing with the waters of the eyes. The second secondary effect, mixing with the eye's waters, has a phenomenological consequence: It causes all kinds of colors to appear. I have suggested that the phenomenological consequence of the secondary effect can be explained if Timaeus held that water is black thus causing a darkening in appearance of the incoming fire. As we shall see in the next section, the chromatic affection involved in the experience of red is complex as well. It involves not only the division of the visual body but a secondary effect as well, mixing with the eye's waters, which also has a phenomenological consequence: It causes a sanguineous appearance. This too can be explained if the eye's waters are black and so compact the incoming chromatic fire.

5. Red

Let us now consider Timaeus account of red. Just as brilliant bodies emit a distinctive kind of fire particle, so red things emit a distinctive kind of fire particle. Again, it is plausible to assume that this difference in kind has to do with the size of the tetrahedra. Concerning

this, Timaeus says of this kind that it is between 'these' (67e6–7), but there is unclarity about this anaphoric reference. Since Timaeus has just been discussing brilliant, it is plausible that the fire particles emitted by brilliant bodies is one of the kinds of fire to which the fire particles emitted by red bodies is being compared. But what is the other kind of fire? Archer-Hind claims that it is the fire that is emitted by white bodies, while Bury claims that it is the fire that is emitted by black bodies.[36] Archer-Hind's reading, that Brisson shares,[37] may be justified in the following manner: Like the fire emitted from brilliant bodies, the fire emitted by red bodies enters they eye and mixes with the water therein to produce a sanguineous appearance that we call 'red' (ἐρυθρός). It thus must be more like the fire emitted from brilliant bodies than the fire emitted from white bodies. Cornford, on the other hand, endorses Bury's reading and cites Aristotle's claim that bright light seen through a dark medium appears red, as when the sun appears through a cloud or smoke.[38] Indeed, Aristotle thinks that red is the intermediary color that is midway between white and black (*De sensu* 4 442a20–5). This, however, can suggest a third interpretation. Perhaps 'these' does not refer to the kind of fire involved in brilliant and either white or black, but simply picks up the earlier opposition between white and black. This would be further reinforced if Levides is right and brilliant is merely a species of white, presumably a lesser

[36] Archer-Hind, *Timaeus*, 250 n8, Brisson, 'Theory', 168, and R.G. Bury, *Plato, Timaeus, Cleitophon, Menexenus, Epistles* (Cambridge, Mass., 1929), 67 n3.

[37] Brisson, 'Theory', 168.

[38] Cornford, *Cosmology*, 277 n2; Aristotle, *Meterologica* 3 4, 374a3.

species.[39] Taylor provides yet another interpretation and sees the contrast between the fire emitted by white bodies and the fire that composes the visual body itself.[40]

The matter is unclear. I suspect, however, that Archer-Hind's interpretation is correct, for the reason already given—that the fire emitted by red bodies, like the fire emitted by brilliant bodies, enters the eye and mixes with the water therein. If Archer-Hind is correct, then, given the assumption that kinds of fire are associated with sizes of fire particles, the fire particles emitted by red bodies are smaller than the fire particles emitted by white bodies and larger than the fire particles emitted by brilliant bodies. Nevertheless, they are small enough and rapid enough to divide the visual body all the way up to the eyes and so mix with their waters. Notice that this is consistent with red being midway between the opposed chromatic extremes. That is a claim about chromatic similarity, and not about the relative size of tetrahedra. And insofar red being midway is consistent with the reason motivating Archer-Hind's and Brisson's interpretation, it is not a good reason for preferring Bury's and Cornford's alternative.

The fire emitted by red bodies, like the fire emitted by brilliant bodies, divides the visual body all the way up to the eye where it mixes with the water of the eye to produce a secondary effect. This secondary effect differs from the secondary effect involved in dazzling visual experiences. First, no tearing is involved in the experience of red. Second, the fire

---

[39] A.V. Levides, 'Why Did Plato Not Suffer Color Blindness, An Interpretation of the Passage on Color Blending in *Timaeus*' ['Color Blindness'] in M. A. Tiverios and D.S. Tsiafakis (eds.), *Color in Ancient Greece, The Role of Color in Ancient Greek Art and Architecture* (Thessaloniki, 2002), 9–22 at 10–1. See also Theophrastus, *De sensibus* 86.

[40] Taylor, *Commentary*, 482.

emitted by brilliant bodies dissolves the passages of the eyes, but the fire emitted by red bodies does not. Each is a kind of flame, each enters the passages of the eyes, so what explains this difference? The fire emitted by brilliant bodies consists in tetrahedra that are smaller and more rapid than the tetrahedra emitted by red bodies. As a consequence, the eye takes in more fire, and as smallness and rapidity contribute to fire's power of division, this fire has a tendency to dissolve ocular passages. In the case of red, the eye takes in less fire, consisting of larger and slower tetrahedra, and this proves insufficient to dissolve such passages. Third, and finally, instead of all kinds of colors appearing as a result of mixing with the waters of the eye, what appears, instead, is a sanguineous appearance that we call 'red' (ἐρυθρός).[41]

How are we to understand this? Why does fire mixing with the waters of the eye have the phenomenological effects that it does? Something appearing red appears darker than something that appears white. So, it seems like the phenomenological effects of mixing with the waters of the eye involves a darkening, in this sense, of what appears. What explains this?

If Timaeus subscribes to the ancient tradition that counts water as black, as he seems to in his explanation of blackened earthenware (60d 2–4) and his discussion of the opaque kind of air (58d1–4), then the water in the eye is itself black, and so compacts the incoming stream of fire. And the fact that the stream of fire that passes through the dark waters of the eye produces an experience of red is a manifestation of red being

[41] In her glossary of Greek color vocabulary, James, *Light and Colour*, 49, observes that ἐρυθρός is 'used in Homer invariably in the context of blood (*Iliad,* X, 482–4) from which the wider meaning is derived.'

intermediary between white and black. The phenomenological consequence of the chromatic fire mixing with the dark waters of the eye differs in the case of perceiving red. Instead of all kinds of colors appearing, a sanguineous appearance is produced. If the perception of red involves the eye taking in less fire, consisting of larger tetrahedra, then the darkening effect of being compacted by the surrounding water will be greater, resulting in this difference in appearance.

There is a puzzling asymmetry, here. Both the appearance of brilliant and red are due, in part, to the darkening of the eye's waters. But whereas a sanguineous appearance involves a uniform darkening, a brilliant appearance involves the appearance of all kinds of colors, not all of which are white. In one case the darkening is uniform, in the other the darkening is non-uniform.[42] What might explain the difference? For all that Timaeus has said, only the relative size and speed and consequent amount of the tetrahedra could explain the difference in effect. Perhaps the high speed of the small incoming tetrahedra emitted by brilliant bodies results in this disorderly effect, the non-uniform darkening of appearance. Perhaps there needs to be a certain number of tetrahedra of passing through dark waters in a certain amount of time to elicit the spectral refraction and that can only be achieved with the small and swift tetrahedra emitted by brilliant bodies.

The chromatic affections involved in seeing brilliant and red are complex. They consist in primary and secondary effects and involve both division and compaction. Moreover, these effects are received in distinct things in distinct locations Whereas the primary effect involves the division of the visual body external to the eye, the secondary effect involves the compaction of the chromatic fire within the eye. If the fundamental

[42] Thanks to Victor Caston for this observation.

opposition in the Timaean color scheme derives from the opposition of division and compaction, then brilliant and red are intermediary colors between white and black, yielding the series: white, brilliant, red, and black, with white and black being the primary opposition.

Taking white and black as opposed extremes, white is the fundamental principle of brightness. Brilliant and red, however, can be understood as two further derivative principles of brightness, albeit limited principles of brightness that are themselves limited to different degrees.[43] Brilliant and red count as principles of brightness given their effect on the visual body. Like white, the fundamental principle of brightness, they divide it. The mixing with the dark waters of the eyes, however, limits the operation of these principles by compacting the incoming stream of chromatic fire, and this gives rise to the characteristic appearances of brilliant and red.

Brilliant and red are derivative limited principles of brightness. They are derivative in that these colors depend upon white and black. Brilliant and red depend upon white and black but not by being mixed from them. Mixing white (λευκός) and black (μέλας) results in gray (φαιός), and not brilliant (στίλβος) and not red (ἐρυθρός) (68b5–c7). Brilliant and red depend upon white and black, not by being mixed from them, but by their complex chromatic affection, the division of the visual body and the compaction of the chromatic fire, involving the same affections as white and black, division and compaction, respectively.

---

[43] On brilliant and red as principles of brightness see James, 'Colour Perception in Byzantium', PhD thesis (University of London, 1989); 96–9, J. Gage, *Colour and Culture, Practice and Meaning from Antiquity to Abstraction* [*Colour and Culture*] (Berkeley and Los Angeles, 1993), 31; James, *Light and Colour*, 57.

Like white, the primary effect brilliant and red is to divide the visual body. And the phenomenologically significant secondary effect, the compaction of the incoming chromatic fire, is the result of the blackness of the eyes' waters.

To get a better sense of this let us briefly consider, first, why mixing white and black could not result in brilliant or red and, second, why and in what sense the division and compaction in the complex chromatic affection presuppose white and black.

The perceptions of brilliant and red involve not only the division of the visual body but the compaction of the chromatic fire. If white divides the visual body, and black compacts it, then there is no way to combine these to reduplicate these complex chromatic affections. Presumably, mixing white and black would result in a color that divides and compacts the visual body, but the chromatic fire would remain uncompacted. White and black, as Timaeus understands them, cannot explain the secondary effects involved in the experiences of brilliant and red, and importantly, these secondary effects have phenomenological consequences.

Timaeus observes that division and compaction are involved, not only in color perception, but in thermal perception and taste as well (67d5–e2). And he claims that these are the same affections and differ only with respect to their cause (67e2–4). By this reasoning, division and compaction in the complex chromatic affections involved in the perceptions of brilliant and red are the same affections involved in the perceptions of white and black. Again, like white, they divide the visual body, and it is the blackness of the eyes' waters that compacts the incoming chromatic fire. Brilliant and red depend upon white and black, not because they are mixed form them, but because their complex affections consist in affections that are the same as the affections of white and black.

Allow me to end our discussion of red with a puzzle and a suggestion. Why does Timaeus to think that red bodies emit fire particles that penetrate the eye? This could not be the expression of a judgment of chromatic brightness. Red is not that bright. What about the experience of red is analogous to the dazzling experience of brilliant such that if the perception of brilliant involved the eye taking in fire particles, then the perception of red involves the eye taking in fire particles, as well, though perhaps to a lesser degree? In what ways might red be akin to brilliant? Why is it plausible to think of red as a principle of brightness?

Timaeus provides no explicit answer. Sometimes, an author provides no answer because there is no answer to be had. To persuade ourselves that this is not the case, we may endeavour to provide an answer on Timaeus' behalf, mindful that it is our answer, even if it is for the sake of Timaeus.

Red is akin to brilliant in its salience and warmth. Red is visually salient. It has a tendency to grab our attention in the way that light in the dark does. And it is not just analogous, attention affects apparent brightness.[44] Red is also warm. Chromatic warmth is an intermodal comparison of color and heat. We can understand chromatic warmth as that aspect of a color that makes the thermal comparison apt. Certain diurnal and seasonal changes in illumination give rise to an increased warmth in color appearance and are associated as well with rising temperatures.[45] Thus, the sun appears red when it first rises

[44] P. Tse, "Voluntary attention modulates the brightness of transparent surfaces', Vision Research 45 (2005), 1095–1098.

[45] The spectral power distribution of daylight varies at different times of the day, in different seasons, and due to different atmospheric conditions. These variations in illumination

and as the earth begins to warm. And certain radiant heat sources can appear red. Consider Democritus' remarks about red (as reported by Theophrastus, *De Sensibus* 75 1-9).[46] He claims that red is composed of the same things that compose heat except that they are larger and that evidence for this is the way we redden when heated. Moreover, Democritus claims that brilliant things contain the most fire and the subtlest while red things contain less fire and of a coarser variety. What moved Democritus to make these claims is reflection on the warmth of redness. Could the salience and warmth of redness move Timaeus to make the parallel claim—that brilliant things emit the most fire and the subtlest, while red things emit less fire and of a coarser variety?

6. Proportion, Divine Bonds, and the Chromatic Unknown

Timaeus prefaces his discussion of color mixture with a warning. It would be foolish to state the exact proportions involved in such mixtures, even if one knew these, since no demonstrative nor even probable reason could be given (68b6–8). And he concludes his discussion of color mixture by charging any experimental inquiry into these proportions with

---

combine with surface color to give rise to different color appearances that may vary in warmth and coolness. These are best observed from a darkened room overlooking the scene, as Monet observed Rouen Cathedral when producing a series of paintings, between 1892 and 1894, that dramatize its color appearance varying with the variation in its illumination.

[46] For discussion see Beare, *Elementary Cognition*, 32 and K. Rudolph, 'Democritus' Theory of Colour' ['Democritus'], *Rhizomata* 7 (2019) 269-305 at 293-6.

impiety. Only God is wise enough and powerful enough to blend the many into one and dissolve the one into many (68c7–d7). So, while we can know which colors need to be mixed to generate another color, it is impossible for mortals to determine by test (βάσανος) the exact proportions involved. Βάσανος, like a lot of Greek epistemological vocabulary, has a judicial origin.[47] Specifically, it derives from the practice of eliciting evidence by torture.[48] So, in the chromatic domain, only God is wise enough and powerful enough to have the authority to deploy this judicial procedure. Even if we somehow came to know these proportions, by the testimony of a god or oracular revelation, say, we would still not understand how mixing colors in these proportions generate the colors that they do, for no demonstrative or even probable reason would be available to us.

The full significance of these enigmatic remarks is unclear. Brisson makes the interesting suggestion that they are a criticism of Empedocles' claim to be equal to a God in knowledge.[49] However they are to be understood, I think that we should resist any cynical interpretation where Timaeus is pre-emptively silencing his critics or providing a license to engage in an Athenian chromatic parlour game.[50] Rather than manifesting a lack of seriousness, these remarks are the expression of a profound humility. For in making them,

---

[47] For discussion see. G.E.R. Lloyd, *Magic, Reason, and Experience, Studies in the Origin and Development of Greek Science* (Cambridge, 1979), ch. 4 and M. Gagarin. 'The Torture of Slaves in Athenian Law', *Classical Philology*, 91 (1996), 1–18.

[48] See, for example, Herodotus, *Histories* 8 110.

[49] Brisson, 'Theory', 173–4.

[50] See, for example, Taylor, *Commentary*, 479–91.

Timaeus concedes that the visible may not be fully understood by the intellect of mortals, thus confessing to a limitation of his cosmological project.

Moreover, and importantly, these remarks turn on an already stated principles, that proportion is the fairest of bonds (31c2–4), and that only the Demiurge can dissolve what He has bound (32b8–c4). This latter principle is used in the argument that the body of the Cosmos is composed of the four primary bodies (32c3–5), in the assurance the Demiurge gives to the Young Gods (41a7–b6), and in the discussion of the shock of embodiment (43d6–7). In the argument concerning the elemental composition of the Cosmos, the opposition of visible fire and tangible earth is overcome by the amity of like proportion.[51] Having been unified in this manner, Timaeus remarks that this unity cannot be undone by anyone but the one that bound them together. Visible fire and tangible earth are united in a three-dimensional sensible whole, the body of the Cosmos, by standing in like proportions to air and water. This whole could only be unbound, and so rent asunder, by He who bound the elements together. This claim will be echoed in the assurances that the Demiurge gives the Young Gods (41a7–b6). The Young Gods come into being by bonds fitted by the Demiurge. The Demiurge assures the Young Gods that while any bond may be dissolved by its maker, only evil would dissolve the bonds of what is well-fitted and good. Thus, though the Young Gods are dissoluble by Demiurgic power, the benevolent and ungrudging nature of the Demiurge insures their continued unity and being.

---

[51] Amity, φιλία, is most likely an allusion to Love in Empedocles's cosmology, though Strife finds no counterpart in Timaeus' speech, see Taylor, *Commentary*, 99–100, Cornford *Cosmology*, 44 n4, and Broadie 2012, 230 n119, for Plato's own explanation for doing without Strife see *Gorgias* 508a.

The chromatic opposed extremes are themselves bound together by intermediary colors that stand to them and to one another in divine proportions. Proportion is the fairest of bonds (31c2–4), and the amity of like proportions overcomes the opposition of extremes to unify the extremes and the intermediary colors into an intelligible ordering. Just as four primary bodies, when combined in various proportions, suffice to determine the whole range of sensible bodies (31b4–329), four colors, when combined in various proportions, suffice to determine the whole range of colors (68b5–d2). But the proportions involved in color mixture are unknowable by mortal intellect, since in order to ascertain these by experiment,[52] one would have to have the power to blend the many into one and dissolve the one into many, and no mortal has this divine power. So, if the Demiurge overcomes the opposition of division and compaction by imposing proportion on intermediaries that unite all in chromatic amity, only He may rend asunder what is thus bound by like proportion.

7. Color Mixture

Timaeus lists nine colors that are the result of mixing the four colors—white (λευκός), black (μέλας), bright (λαμπρός) or brilliant (στίλβος), and red (ἐρυθρός)—or the further results of such mixtures (68b5–c7). These are:

(1) golden = bright + red + white

ξανθός = λαμπρός + ἐρυθρός + λευκός

[52] These proportions could only be determined, if at all, empirically, through physical experimentation. They could not be known by reason alone. After all, the sensible character of the Cosmos is not the work of Reason alone but Reason's persuasion of Necessity.

(2) purple = red + black + white

ἀλουργός = ἐρυθρός + μέλας + λευκός

(3) violet = black + purple

ὄρφνινος = μέλας + ἀλουργός

(4) tawny = golden + grey

πυρρός = ξανθός + φαιός

(5) gray = white + black

φαιός = λευκός + μέλας

(6) yellow = white + golden

ὠχρός = λευκός + ξανθός

(7) dark blue = white + bright + black

κυάνεος = λευκός + λαμπρός + μέλας

(8) light blue = dark blue + white

γλαυκός = κυάνεος + λευκός

(9) leek green = tawny + black

πράσινος = πυρρός + μέλας

The precise sense of Greek color terms is notoriously difficult to capture in translation, and so the translations provided here are only rough equivalents and do not capture precise hue boundaries.[53]

---

[53] For useful discussion of these terms as they occur in the *Timaeus* see Platnauer, 'Color-Perception', Taylor, *Commentary*, 483–5; Bruno, *Form and Color in Greek Painting* [*Form and Color*] (New York, 1977), chapter 10; Levides 'Color Blindness'; and Struycken, 'Colour mixtures according to Democritus and Plato' ['Democritus and Plato'], *Mnemosyne, Fourth*

If we resolve the combinations with mixed colors into the colors from which they are themselves mixed we get:

(1) golden = bright + red + white

ξανθός = λαμπρός + ἐρυθρός + λευκός

(2) purple = red + black + white

ἁλουργός = ἐρυθρός + μέλας + λευκός

(3) violet = black + (red + black + white)

ὄρφνινος = μέλας + (ἐρυθρός + μέλας + λευκός)

(4) tawny = (bright + red + white) + (white + black)

πυρρός = (λαμπρός + ἐρυθρός + λευκός) + (λευκός + μέλας)

(5) gray = white + black

φαιός = λευκός + μέλας

Series, 56 (2003), 273–305. On the use of classical Greek color vocabulary more generally, see E. Veckenstedt, *Geschichte der griechischen Farbenlehre* (Paderborn, 1888); A.E. Kober, *The Use of Color Terms in the Greek Poets to 146BC* (New York, 1932); F.E. Wallace, *Colour in Homer and in Ancient Art*, (Northampton, 1927); D. Young, 'The Greeks' Colour Sense', Review of the Society for Hellenic Travel 4 (1964) 42–6; E. Irwin, *Color Terms in Greek Poetry* (Toronto, 1974); C.J. Rowe, 'Conceptions of Colour and Colour-Symbolism in the Ancient World' in A Portmann and R. Ritsema (eds.), *The Realms of Colour* (Leiden, 1974); H. Dürebeck, *Zur Charakteristik der griechischen Farbenzeichnungen* (Bonn, 1977); P.G. Maxwell-Stewart, *Studies in Greek Colour Terminology* (Leiden, 1981); L. Villard, 'Couleurs et maladies dans la Collection Hippocratique' ['Couleurs et maladies'] in L. Villard: *Couleurs et vision dans l'antiquité classique*. (Rouen, 2002).

(6) yellow = white + (bright + red + white)

ὠχρός = λευκός + (λαμπρός + ἐρυθρός + λευκός)

(7) dark blue = white + bright + black

κυάνεος = λευκός + λαμπρός + μέλας

(8) light blue = (white + bright + black) + white

γλαυκός = (λευκός + λαμπρός + μέλας) + λευκός

(9) leek green = (bright + red + white) + (white + black) + black

πράσινος = (λαμπρός + ἐρυθρός + λευκός) + (λευκός + μέλας) + μέλας [54]

Inspection of this table shows that bright (λαμπρός) and red (ἐρυθρός) never combine together by themselves to generate a mixed color. They must always be combined with either white (λευκός) or black (μέλας) to generate a mixed color. This contrasts with the other two unmixed colors, white (λευκός) can combine with black (μέλας) to generate gray

[54] Compare the tables provided by James, *Light and Colour*, 56-7, Brisson, 'Theory', 175, Brisson, *Le Même et l'Autre dans la Structure Ontologique du* Timée *de Platon* (1998), 466–7, 600, and R. Kuehni, *Color Space and Its Divisions: Color Order from Antiquity to the Present* (Hoboken, 2003), 23. I find an aspect of Brisson's notation potentially misleading given Timaeus' warning about our ability to know, let alone understand, the proportions involved in color mixture. Consider, for example, Brisson's representation of the color combination involved in the generation of violet. Let A be white, B black, and C red, then the color combination that generates violet is represented as:

(A + B + C) + B = A + 2B + C

The occurrence of 2 is egregious as it can misleadingly suggest that the color mixture involves two parts black. But, as Brisson himself knows well, Timaeus claims no such thing.

(φαιός). And white need not be combined with black to generate a mixed color (as in the formula for golden, ξανθός). The lack of independence of bright (λαμπρός) and red (ἐρυθρός) in the color-mixing scheme and their complex affections depending upon the affections of white (λευκός) and black (μέλας) are manifestations of their derivative status and the more fundamental status of white and black.

Let us now consider the brightness ordering generated by Timaeus' account of color mixture. Ordering all thirteen colors from light to dark, we get:

(1) white (λευκός)

(2) bright (λαμπρός) or brilliant (στίλβος)

(3) yellow (ὠχρός)

(4) golden (ξανθός)

(5) tawny (πυρρός)

(6) leek green (πράσινος)

(7) red (ἐρυθρός)

(8) light blue (γλαυκός)

(9) dark blue (κυάνεος)

(10) purple (ἁλουργός)

(11) violet (ὄρφνινος)

(12) gray (φαιός)

(13) black (μέλας)

The list was generated given the following assumptions. First, that the four unmixed colors ordered in terms of chromatic brightness are white, brilliant, red, and black. Second, that brilliant is close to white in chromatic brightness. Third, that like the Aristotelian color scheme (*De sensu* 4 442a20–5), red is midway between white and black. These assumptions

were then applied to Timaeus' color combinations to yield the brightness ordering. Consider, by way of example, the Timaean formula for golden: golden (ξανθός) = bright (λαμπρός) + red (ἐρυθρός) + white (λευκός). Given the absence of black (μέλας), and given the stated assumptions concerning the relative brightness of white (λευκός), bright (λαμπρός), and red (ἐρυθρός), we can surmise ξανθός should occur reasonably high in the brightness ordering. How good of a brightness ordering do these assumptions generate when applied to the Timaean formulae? As the unknowable proportions can make a difference, the ordering could only be an estimate, but it conforms reasonably well to intuitive judgments of relative brightness. There are difficulties in understanding the colors as intermediaries in the opposition between white and black.[55] However, if we bracket these difficulties, this is a reasonably comprehensible ordering and less mysterious than some commentators have made it out to be.[56]

---

[55] See Kalderon, *Form*, ch. 6.3.

[56] There is, of course, room for disagreement. Compare the alternative brightness ordering provided by James, *Light and Colour*, 57. She provides a list of eleven colors, the mixed colors arrayed between white and black, thus excluding brilliant and red: λευκός, ὠχρός, ξανθός, πυρρός, φαιός, γλαυκός, ἀλουργός, πράσινος, κυάνεος, ὀρφνινος, μέλας. First, I am happy at the degree of convergence between my independently arrived at brightness ordering and James'. The main differences concern the positions of gray, φαιός (James places it roughly midway whereas I place it adjacent to μέλας) and πράσινος (which I count as significantly brighter). The other difference, the placement of purple, ἀλουργός, is smaller and less significant. That gray is midway does not follow from its Timaean formula since he declines to specify the proportion of white and black mixed, and it would be

8. Interpreting Timaean Color Mixture

How are we to understand color mixture as Timaeus understands it? Attempts have been made to understand mixture, here, on the model of the painter's practice of pigment mixture. Bruno's account is particularly interesting.[57] The painter's practice of pigment mixture may have influenced Plato's thinking, at least indirectly,[58] but, in the first instance, we should try to understand Timaeus' account of color mixture in terms of the emission of

---

impious to assume that it is one–one. (Aristotle in *De sensu* 4, 442a20–5 counts gray as a kind of black, though elsewhere he treats it as an intermediary color, *Categoriae* 10, 12a18, *Topica* 1 15, 106b5, *Metaphysica* 10 6, 1056a27.) Importantly, these disagreements are not about judgments of relative brightness but are rather disagreements in lexical semantics. Despite these disagreements, our lists agree more than they disagree and we both believe that the Timaean color scheme yields a reasonably comprehensible brightness ordering.

[57] Bruno, *Form and Color*, ch. 10, though see Gage, *Colour and Culture*, 29–31, James, *Light and Colour*, 55 for criticism; Cornford *Cosmology*, 278 and Levides, 'Color Blindness' defend this general approach, and Struycken, 'Democritus and Plato', criticizes it, though offers, in effect, a mere generalization of this approach.

[58] Though the author of the *Anonymous Prolegomena to Platonic Philosophy* 13 13–5 surely confabulates when they claim that Plato had practical experience as an artist: 'He went to painters to learn the mixing of colours in their manifold combinations; this enabled him to write a long passage on colours in the *Timaeus*.' L.G. Westernick (Amsterdam, 1962).

fiery effluences that cause of chromatic affections. There are historical, textual, and philosophical reasons for this.

The historical reason concerns the observed general tendency for the Greeks in antiquity to understand colors in terms of relative brightness. This occurs in both literary and philosophical sources such as Homer, Parmenides, Empedocles, and, later, Aristotle. Plato knew these sources and was in many ways influenced by them, it would be unsurprising should a commitment to this ancient tradition be manifest in Timaeus' account.

The textual reason concerns a consequence of the Timaean account of color. According to Timaeus, colors cause chromatic affections, affections of the visual body and the eye from which it issued that give rise to the visual perception. If colors cause chromatic affections, then it would be natural to suppose that color combinations are combinations of these causes. Moreover, in arguing that the body of the Cosmos is composed of the four primary bodies, Timaeus held that powers may stand in proportionate ratios.[59] Of course, more needs to be said about what the combination of causes in various proportions amounts to. But given that colors just are these causes, their combination must be combinations of these causes. A mixture of anything else would not be a color mixture, at least by Timaeus' lights.

The philosophical reason concerns the distinction between color and pigment mixture. The colors are not pigments, and so color mixture is not pigment mixture. It is important to distinguish the mixture of colors that generate different colors from the mixture of bodies that generate differently colored bodies. Pigment mixture is a mixture of

[59] 31c4–32a8, for discussion see P. Pritchard, 'The meaning of Δύναμις at 31c', *Phronesis* 35 (1990) 182-93.

bodies that generate differently colored bodies. So, it would be preferable to understand color mixture in terms other than pigment mixture, especially in light of the material recalcitrance of the latter. Thus, for example, the color mixing that results from mixing pigments is a subtractive process, and Helmholtz showed that not every color determined by an additive process, such as the mixing of colored lights, can be matched by a color determined by a subtractive process, such as mixing pigments.[60] Helmholtz's demonstration was unavailable to the ancients, but it is not anachronistic to suppose that they could mark the distinction between color and pigment mixture. Thus, Aristotle denies that all colors can be reproduced with pigment mixture, *Meterologica* 372a2–9, and criticizes attempts to understand color mixture in terms of pigment mixture in *De sensu* 3 (a position perhaps echoed by the Peripatetic author of *De coloribus* 2 792b17–21). The distinction between pigment mixture and color mixture is drawn in antiquity at least as early as Aristotle, and so it is at the very least not ruled out that Timaeus may be read as subscribing to it as well.

Ierodiakonou proposes an interpretation of Timaeus' account of color mixture which does not conflate it with an account of pigment mixture and is thus of the right kind.[61] Ierodiakonou begins by observing that the terms division and compaction appear in Timaeus' explanation of the cycle of elemental transformation (58b7). In certain circumstances, smaller primary bodies divide larger ones with the result that, for example, we get two tetrahedra of fire from one octahedron of air. Similarly, in certain circumstances, larger primary bodies may compress smaller ones so as to combine them such that we get

---

[60] H. von Helmholtz, 'On the Theory of Compound Colors', *Philosophical Magazine* 4 (1852) 519-535.

[61] Ierodiakonou, 'Plato's Theory'.

one octahedron of air from two tetrahedra of fire. Her suggestion, then, is to apply this model to the division and compaction of the visual body.

If the fire particles emitted from a colored body are smaller than the fire particles that compose the visual body, then these are broken down into smaller tetrahedra. And if the fire particles emitted from a colored body are larger than the fire particles that compose the visual body, then these are compressed and so combined into larger tetrahedra. So Ierodiakonou is advancing a specific interpretation of division and compaction here. The visual body is divided by dividing the tetrahedra that compose it and is compacted by combining smaller tetrahedra into larger tetrahedra. Ierodiakonou is also committed to a specific interpretation of what the chromatic tetrahedra is smaller or larger than, namely, the tetrahedra that compose the visual body (as opposed, for example, to the visual body itself).

It is now open to Ierodiakonou to understand color mixture in terms of the mixture different-sized tetrahedra in the visual body as determined by the operations of division and compaction:

> Let us take, for example, the simple case of the colour grey which is said to be a mixture of white and black. This, I suggest, is to be understood in the following way: a grey body emits fire-particles of two different sizes; namely they are pyramids which, separated according to size, are of the kind emitted by white and by black bodies, respectively. The pyramids of these two different sizes emitted by the grey body interact with and transform the particles of the visual body into smaller and

larger particles so that the visual body ends up containing the same proportion of pyramids of these two sizes as the grey body emits.[62]

Ierodiakonou's account is both ingenious and of the right kind, but is it fully adequate?

White and black bodies dividing and compacting the visual body may produce in it smaller and larger tetrahedra, but is there reason to think that red and brilliant bodies themselves produce tetrahedra of distinctive sizes within the visual body? Timaeus never says as much. Moreover, their eliciting the visual experiences they do is not due solely to their effect on the visual body but is due as well to their secondary effect on the water of the eye. But this is downstream from the visual body (relative to the motion of the fire particles emitted from the colored body), no matter the sizes of tetrahedra from which the visual body is composed.

These downstream secondary effects have phenomenological consequences. In the case of brilliant the mixing of the stream of fire with the eye's waters causes all kinds of colors to appear. And in the case of red, the mixing of the stream of fire with the eye's waters causes a sanguineous appearance. The resulting proportion of tetrahedra in the visual body are explanatorily irrelevant to these phenomenological effects which are explicitly claimed to result from mixing with the waters of the eye.

Furthermore, since the secondary effect is downstream, division cannot merely mean the division of constituent tetrahedra, it must mean, as well, the division of the visual body as a whole. Otherwise, how would the small and swift fiery effluences reach the dark waters of the eye? These are distinct notions. The visual body may be divided as a whole without dividing any of the constituent tetrahedra. Conversely, all the constituent

[62] Ierodiakonou, 'Plato's Theory', 228.

tetrahedra may be divided and the whole remain undivided, albeit now composed of finer parts. In order to reach the dark waters of the eye the stream of tetrahedra must divide the visible body as a whole, whether or not the tetrahedra that compose the visible body are themselves divided.

Ierodiakonou's interpretation of what the chromatic tetrahedra are smaller or larger than, namely, the tetrahedra that compose the visual body, may also be questioned. Timaeus never claims as much. Indeed, Timaeus claims, instead, that the effluences are proportional to the visual body (ὄψει σύμμετρα, 67c7), not the tetrahedra that compose it.

Ierodiakonou's interpretation of division of the visual body, as the division of its constituent tetrahedra, requires that tetrahedra divide tetrahedra. And while it is true that in the cycle of elemental transformation, smaller primary bodies may divide larger primary bodies, and larger primary bodies may compact and so combine smaller primary bodies, these are all cases of primary bodies of different kinds. Timaeus never explicitly says that that smaller fire particles may divide larger fire particles into their constituent triangles.

So, while Ierodiakonou's account of Timaean color mixture is both ingenious and of the right kind, I am hesitant to endorse it. Given the phenomenological consequences of the secondary effects of mixing with the eye's waters, there must be more to the division of the visual body than dividing the tetrahedra that compose it, and, hence, color mixture could not be the result of recombining the parts thus decomposed.

9. The Minimalist Interpretation

What Ierodiakonou gets right is that color mixture involves combining the causes of chromatic affections. She plausibly claims that gray bodies emit the same kind of effluences

as white and black bodies since these are the causes of division and compaction, the chromatic affections that give rise to the perceptions of white and black. Even if we reject her account of color mixture in terms of the resultant proportions of different-sized tetrahedra in the visual body as determined by the operations of division and compaction, we may yet insist that color mixture should be understood, at least in part, in terms of the combination of the causes of the chromatic affections.

Accounting for color mixture, as Bruno does, in terms of pigment mixture is to offer a substantive explanation of the TImaean formulae. Accounting for color mixture, as Ierodiakonou does, in terms of the resulting proportion of differently sized tetrahedra in the visual body is, similarly, a substantive explanation. Perhaps no substantive explanation is to be had. Consider a minimalist alternative. The alternative is mimimalist in the sense that it offers no substantive explanation of the Timaean formulae: Colors are causes of chromatic affections, and there is no more to their mixture than is given by the affections of the unmixed colors and the list of color combinations described by the Timaean formulae.

Associated with white, brilliant, red, and black are distinct affections of the visual body or the eyes from which it issues depending upon the size and rapidity of the fire particles emitted from the colored body. Recall that there are four of them:

(1) White bodies divide the visual body with small and rapid fire particles

(2) Brilliant bodies divide the visual body with smaller and more rapid fire particles that mix with the waters of the eye that compact them

(3) Red bodies divide the visual body with larger and less rapid fire particles (though smaller and more rapid than the fire particles emitted by white bodes) that mix with the waters of the eye that compact them

(4) Black bodies compact the visual body with the largest and slowest of the fire particles

The color combinations that Timaeus describes can be understood as combinations of the causes of these affections. Consider for example the Timaean formula for purple: purple (ἀλουργός) = red (ἐρυθρός) + black (μέλας) + white (λευκός). Purple bodies will emit small and large fire particles but where there are two grades of small particles. The large particles, the slowest, will compact the visual body while the small particles will divide it. The smallest and fastest of these, however, divide the visual body all the way up to the eye where they mix with the eye's water and are compacted by it. Thus, purple bodies will act upon the visual body and the eye from which it issues in the ways that white, black, and red bodies do and thus combine these in some unknowable proportion. And so on for all the other color combinations that Timaeus describes.

Combining the list of the four chromatic affections with the list of Timaeus' color combinations where the combinations with mixed colors are resolved into combinations of colors from which they were mixed, yields a reasonably comprehensible and comprehensive account of color mixture. It is at least as comprehensible as the ordering of the colors from light to dark that it generates, and as we have seen, it does indeed generate a reasonably comprehensible brightness ordering.[63] And with respect to comprehensiveness, all that is

[63] As James, *Light and Color*, 56, has observed: 'when they are seen as points on a black-white linear scale, one concerned with relating colours through their proportions of light and dark, then a plausible colour scale can be constructed and sense made of out the mixtures.' The minimalist interpretation is due to James' overall approach, though I am uncertain to what extent, if at all, she would accept the terms in which I have expressed it.

missing is what Timaeus claims mortal intellects could never have, knowledge and understanding of the proportions involved in such combinations.

White and black are the opposed extremes of the colors. They unmixed colors include, as well, two bright colors, brilliant and red. While not mixed from white and black, as principles of brightness, brilliant and red depend upon white and black. They depend upon white in their primary effect, in that each, like white, involves the power to divide the visual body. And they depend upon black in their secondary effect because the incoming chromatic fire is compacted by the black waters of the eye. While the exact proportions are unknown to us, the Timaean formulae describe the manner in which the mixed colors are proportionally bound in chromatic unity. Thus, the colors are proportionally arrayed in between the opposed extremes of white and black. And the visual affections, as a whole, including the primary and secondary effects, are a proportional response to the unmixed colors—white, brilliant, red, and black. These affections when combined in some unknowable proportion in accordance with the Timaean formulae give rise to the experience of the mixed colors. Thus, color perception, generally, is a proportional response to qualities proportionally arrayed between opposed extremes and thus constitutes a measure of such qualities. And the awareness that such perception affords us is an awareness of what is thus measured.

10. Against Democritus

On the present interpretation, Timaeus can be understood as accommodating Democritus' claim that the mixture of four colors suffices for the generation of the colors within an older

chromatic tradition that sees white and black as the fundamental chromatic opposition.[64] Timaeus departs from the four-color scheme in substituting brilliant for green (χλωπός). But, importantly, the substitution preserves the relative order of brightness. Brilliant, like green, is brighter than red and darker than white. And whereas Democritus only posits seven generated colors, Timaeus posits nine. In this way, it is an elaboration. And while some of the Democritean color combinations are preserved in the Timaean color scheme, there are adjustments given the substitution of brilliant for green, but in a way that preserves the overall structure.

Perhaps this accommodation of the Democritean color scheme within the older tradition is an instance of Plato's tacit rivalry with Democritean natural philosophy.[65]

---

[64] Timaeus' account of color mixture is usefully compared to Democritus' with which there are points of contact, for example, in the mixture that generates golden (ξανθός), Theophrastus, *De sensibus* 76–8. On Democritus' influence on Timaeus on color mixture see Beare, *Elementary Cognition*, 53; Taylor, *Commentary*, 479; E.C. Keuls, *Plato and Greek Painting* (Leiden, 1978), ch.8, James, *Light and Color*, ch.3; Struycken 'Democritus and Plato'; Ierodiakonou, 'Basic and Mixed Colours in Empedocles and Plato' in M. Carastro (ed.), *L'antiquité en couleurs, Catégories, practiques, représentations* (Grenoble, 2009), 119–30; and Rudolph, 'Democritus'.

[65] Diogenes Laertius, *Vitae Philosophorum* 9.40, reports Aristoxenus' claim that Plato wished to burn all the writings of Democritus. Even if apocryphal, the competitive attitude expressed by the anecdote may have been genuine. Though Plato never directly discusses Democritus, his student Aristotle does extensively, and we can be sure that Plato was

Democritus had written an entire book on color,[66] and his claim that the mixture of four colors suffice to generate the colors was shared with medical and artistic traditions. Thus, the medical tradition associated four colors with blood, phlegm, and black and yellow bile.[67] And there is literary and archaeological evidence that fifth century BCE painters restricted their palette to four colors.[68]

Moreover, accommodating Democritus' four-color scheme in a way that preserves the fundamental opposition between white and black would explain why Timaeus is not subject to Theophrastus' criticism of Democritus (*De sensibus* 79). All that was needed was to postulate, in addition to whiteness, two further ways of increasing chromatic brightness that, while distinct, themselves depend upon white and black. Brightness is increased, not the way white bodies do, by emitting small particles that divide the visual body, but by emitting even smaller particles that divide the visual body all the way up to the eye and are themselves compacted when they mix with the eye's waters. These ways of reducing brightness differ in the proportion of fire and water in the mixture that they elicit in the

---

familiar with the writings that Aristoxenus purports he wished to burn. On their rivalry, see W.K.C. Guthrie, *A History of Greek Philosophy* 2 (Cambridge, 1965), 462.

[66] Diogenes Laertius, *Vitae Philosophorum* 9.46.

[67] In the Hippocratic corpus, *Peri Physios Anthropon*, chs. 4–5. For discussion see J. Longrigg, 'Philosophy and Medicine: Some Early Interactions', *Harvard Studies in Classical Philology*, 67 (1963), 147–75 at 153 and L. Villard, 'Couleurs et maladies'.

[68] Empedocles DK 31B23; Cicero, *Brutus* (*De claris oratoribus*) 70; Pliny, *Naturalis historia*, 35.29.44, 50. For discussion see Bruno, *Form and Color*, 56–7. Bruno, *Form and Color*, ch. 1, discusses the tombs at Kazanlak and Lefkadia.

eyes. They may differ in this way, but they are alike in that, though not the result of mixing white and black, neither are they wholly independent of white and black—division and compaction involved in the complex affections of dazzling experiences and experiences of red are the same kind of affections produced by white and black. That brilliant and red cannot be combined by themselves to generate a color but must be combined with either white or black to do so is further evidence of their derivative nature.

The way that Timaeus' account diverges from Empedocles' would also be explained, at least in part. Theophrastus objects to Empedocles' account that while he has explained the perception of white in terms of the reception of fiery effluences and the perception of black in terms of the reception of watery effluences, he has not explained the perception of any other color (*De Sensibus* 17). However, Empedocles may be understood as claiming that the perception of the rest of the colors involve different proportions of fire and water received through the eyes' passages.[69] Timaeus accepts the basic idea that white and black are the fundamental chromatic opposition. Timaeus also accepts the Eleatic idea that the intermediary colors should be understood in terms of mixtures of various proportions (even if knowledge of these proportions would require a God's knowledge that Empedocles' impiously claims for himself). However, accommodating Democritus' four-color scheme within the older tradition that Timaeus shares with Empedocles required postulating two further ways of increasing brightness beyond the way that white bodies do, and this, in turn, required corresponding adjustments to the Empedoclean scheme. For example, that only some chromatic effluences enter the eye, those emitted by brilliant and red bodies, is a

[69] See, Ierodiakonou, 'Empedocles' and Kalderon, *Form*, ch. 5.4, an idea that may have Parmenidean provenance, see Kalderon, *Form*, ch. 5.3.

departure from Empedocles that results from such an adjustment, as is the revised role of the eye's water, to limit the operation of these principles of brightness.[70] Thus, Taylor was wrong to see Timaeus account of color and its perception as simply an application of Empedocles', just as Archer-Hind was wrong to deny any Empedoclean influence.

It would be misleading to speak of Democritus' influence on Plato here. Rather, Plato is dispensing with a rival account. Theophrastus' complaint against Democritus, that he posits four primary colors instead of two, signals that Democritus' account was viewed as a novel incommensurable alternative to the ancient view. Showing how a four-color account like Democritus' can be interpreted within a variant of the ancient view establishes that it is not in fact an incommensurable alternative. Consider the following analogy from the history of mathematics. Constructivism was billed as an incommensurable alternative to classical mathematics, but that debate ended when it was shown how to interpret constructivist mathematics within classical mathematics. On that basis, most mathematicians ceased to consider constructivism a potential rival to classical mathematics. Similarly, in showing how a four-color scheme may be explained in terms that take white and black as the fundamental chromatic opposition, Democritus' theory was no longer a potential rival to the ancient view, at least as elaborated by Timaeus.[71]

---

[70] For Empedocles, the eyes contain reservoirs that receive watery chromatic effluences. For Timaeus, the eyes do not receive watery effluences but fiery ones and these are quenched in the waters of the eye.

[71] Thanks to Justin Broackes, José Filipe de Silva, Victor Caston, and the anonymous reviewer for discussion and or comments. Special thanks to the participants of my seminar at UCL who had to suffer through my presenting this material over Zoom.

Bibliography

Archer-Hind, R.D., *The Timaeus of Plato* (London and New York, 1888).

Brisson, L., 'Plato's Theory of Sense Perception in the *Timaeus*: How It Works and What It Means', *Proceedings of the Boston Area Colloquium in Ancient Philosophy*, 13 (1997), 147–176.

Brisson, L., *Le Même et l'Autre dans la Structure Ontologique du* Timée *de Platon* (Sankt Augustin, 1998).

Broadie, S., *Nature and Divinity in Plato's* Timaeus (Cambridge, 2012).

Bruno, V.J., *Form and Color in Greek Painting* (New York, 1977).

Burnet, J., *Platonis Opera* 4 (Oxford, 1962).

Bury, R.G., *Plato, Timaeus, Critias, Cleitophon, Menexenus, Epistles* (Cambridge, 1929).

Cook Wilson, J., *On the Interpretation of Plato's* Timaeus*, Critical Studies with Special Reference to a Recent Edition* (London, 1889).

Cornford, F.M., *Plato's Cosmology, The Timaeus of Plato*, (London, 1935).

Crowther, T., 'In Touch with the Look of Solidity' in T. Crowther and C. Mac Cumhaill (eds.), *Perceptual Ephemera* (Oxford, 2018), 260–88.

Curd, P., 'Empedocles on Sensation, Perception, and Thought', *History of Philosophy & Logical Analysis* 19 (2016), 38–57.

Diels, H., 'Gorgias und Empedokles', *SB Berlin* (1884), 343–68.

Diels, H. and Kranz, W., *Die Fragmente der Vorsokratiker* (Berlin, 1974).

Dürebeck, H., *Zur Charakteristik der griechischen Farbenzeichnungen* (Bonn, 1977).

Fairchild, M.D., *Color Appearance Models* (West Sussex, 2005).

Furley, D. and Wildberg, C., *Philoponus, Corollaries on Place and Void with Simplicius, Against Philoponus on the Eternity of the World*. (London, 1991).

Gagarin, M., 'The Torture of Slaves in Athenian Law', *Classical Philology*, 91 (1996), 1–18.

Gage, J., *Colour and Culture, Practice and Meaning from Antiquity to Abstraction* (Berkeley and Los Angeles, 1993).

Gladstone, W.E., *Studies on Homer and the Homeric Age*, iii (Oxford, 1858).

Gregoric, P., 'Aristotle's Transparency: Comments on Ierodiakonou, "Aristotle and Alexander of Aphrodisias on Colour"' in B. Bydén and F. Radovic (eds.), *The Parva Naturalia in Greek, Arabic and Latin Aristotelianism* [*Parva*] (Cham, 2018), 91–8.

Guthrie, W.K.C., *A History of Greek Philosophy* 2 (Cambridge, 1965).

Hahm, D., 'Early Hellenistic Theories of Vision and the Perception of Color' in P.K. Machamer and R.G. Turnbull (eds.), *Studies in Perception: Interrelations in the History of Philosophy and Science* (Columbus, 1978), 60-95.

Helmholtz, H., 'On the Theory of Compound Colors', *Philosophical Magazine*, 4 (1852), 519–535.

Ierodiakonou, K., 'Empedocles on Colour and Colour Vision' *Oxford Studies in Ancient Philosophy*, 29 (2005), 1–38.

Ierodiakonou, K., 'Plato's Theory of Colours in the *Timaeus*', *Rhizai, A Journal for Ancient Philosophy of Science*, 2 (2005), 219–233.

Ierodiakonou, K., 'Basic and Mixed Colours in Empedocles and Plato' in M. Carastro (ed.), *L'antiquité en couleurs, Catégories, practiques, représentations* (Grenoble, 2009), 119–30.

Ierodiakonou, K., 'Aristotle and Alexander of Aphrodisias on Colour' in B. Bydén and F. Radovic (eds.), *The Parva Naturalia in Greek, Arabic and Latin Aristotelianism* [*Parva*] (Cham, 2018), 77–90.

Inwood, B., *The Poem of Empedocles, A Text and Translation with an Introduction* (Toronto, 2001).

Irwin, E., *Color Terms in Greek Poetry* (Toronto, 1974).

James, L., *Light and Colour in Byzantine Art* (Oxford, 1996).

Johansen, T.K., *Plato's Natural Philosophy, A Study of the Timaeus-Critias* (Cambridge, 2004).

Kalderon, M.E., *Form without Matter, Empedocles and Aristotle on Color Perception* (Oxford, 2015).

Kalderon, M.E., 'Aristotle on Transparency' in T. Crowther and C. Mac Cumhaill (eds.), *Perceptual Ephemera* (Oxford, 2018), 219–37.

Kelsey, S., *Mind and World in Aristotle's De Anima* (Cambridge, 2022).

Keuls, E.C., *Plato and Greek Painting* (Leiden, 1978).

Kober, A.E., *The Use of Color Terms in the Greek Poets to 146BC* (New York, 1932).

Kuehni, R.G., *Color Space and Its Divisions: Color Order from Antiquity to the Present* (Hoboken, 2003).

Levides, A.V., 'Why Did Plato Not Suffer of Color Blindness? An Interpretation of the Passage on Color Blending in *Timaeus*' in M.A. Tiverios and D.S. Tsiafakis (eds.), *Color in Ancient Greece, The Role of Color in Ancient Greek Art and Architecture* (Thessaloniki, 2002) 9–22.

Lloyd, G.E.R., *Magic, Reason and Experience, Studies in the Origin and Development of Greek Science* (Cambridge, 1979).

Lloyd, G.E.R., *Cognitive Variations* (Oxford, 2007).

Long, A.A., 'Thinking and Sense-Perception in Empedocles: Mysticism or Materialism', *The Classical Quarterly* 16 (1966), 256-276.

Long, A.A., ‘Theophrastus’ *De sensibus* on Plato’ in Kalgra et al. (eds.), *Polyhistor: Papers Offered to J. Mansfeld on the Occasion of His Sixtieth Birthday* (Leiden, 1996), 345–62.

Martin, T.H., *Études sur le Timée de Platon* (Paris, 1841).

Longrigg, J., ‘Philosophy and Medicine: Some Early Interactions’, *Harvard Studies in Classical Philology*, 67 (1963), 147–75.

Maxwell-Stewart, P.G., *Studies in Greek Colour Terminology* (Leiden, 1981).

O’Brien, D., *Theories of Weight in the Ancient World*, volume 2 (Paris and Leiden, 1984).

Osborne, H., ‘Colour Concepts of the Ancient Greeks’, *British Journal of Aesthetics*, 8 (1968), 269–283.

Platnauer, M., ‘Greek Color-Perception’, *The Classical Quarterly*, 15 (1921), 153–162.

Pritchard, P., ‘The Meaning of Δύναμις at 31c’, *Phronesis* 35 (1990), 182–93.

Rowe, C.J., ‘Conceptions of Colour and Colour-Symbolism in the Ancient World’ in A. Portmann and R. Ritsema (eds.), *The Realms of Colour* (Leiden, 1974).

Rudolph, K., ‘Democritus’ Theory of Colour’, *Rhizomata* 7 (2019) 269–305.

Sansone, D., ‘Socrates’ “Tragic” Definition of Color (Pl. Meno 76D–E)’, *Classical Philology*, 91 (1996), 339–45.

Sedley, D.N., ‘Empedocles’ Theory of Vision and Theophrastus’ *De Sensibus*’ in W.W. Fortenbraugh and D. Gutas (eds.), *Theophrastus: His Psychological, Doxographical and Scientific Writings* (New Brunswick, 1992) 20–31.

Sorabji, R., ‘Aristotle, Mathematics, and Colour’, *The Classical Quarterly*, 22 (1972): 293–308.

Strange, S., ‘The Double Explanation in the *Timaeus*’, *Ancient Philosophy* 5 (1985), 25–39.

Stratton, G.M., *Theophrastus and the Greek Physiological Psychology before Aristotle* (New York, 1917).

Strawson, P.F., *The Bounds of Sense: An Essay on Kant's Critique of Pure Reason* (London, 1966).

Struycken, P., 'Colour mixtures according to Democritus and Plato', *Mnemosyne, Fourth Series*, 56 (2003), 273–305.

Taylor, A.E., *A Commentary on Plato's Timaeus* (Oxford, 1928).

Tse, P., "Voluntary Attention Modulates the Brightness of Transparent Surfaces', *Vision Research* 45 (2005), 1095–1098.

Veckenstedt, E., *Geschichte der griechischen Farbenlehre* (Paderborn, 1888)

Villard, L., "Couleurs et maladies dans la Collection Hippocratique" in L. Villard: *Couleurs et vision dans l'antiquité classique*. (Rouen, 2002).

Vitelli, H., *Ionnis Philoponi, In Aristotelis Physicorum, Libros Tres Priores, Commentaria* (Berlin, 1882-90)

Vlastos, G., 'Plato's Supposed Theory of Irregular Atomic Figures', *Isis*, 58 (1967), 204–9.

Wallace, F.E., *Colour in Homer and in Ancient Art* (Northampton, 1927).

Westernick, L.G., *Anonymous Prolegomena to Platonic Philosophy* (Amsterdam, 1962).

Wright, M.R., *Empedocles: The Extant Fragments* (New Haven, 1981).

Young, D., 'The Greeks' Colour Sense', *Review of the Society for Hellenic Travel* 4 (1964) 42-6.